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ABSTRACT

Kansas and nearby Missouri are among the half-dozen states in America having the greatest frequency of tornadoes of any region in the world. This booklet describes a districtwide approach of designing and constructing tornado-resistant shelters as integrated parts of the school facilities. The design criteria for tornado protection also resulted in fallout radiation protection. The technical data for, drawings, and photographs of 18 schools are included. (Photographs and some floor plan sketches may reproduce poorly.) (Author/MLF)

SCHOOLS IN KANSAS WITH TORNADO PROTECTION

U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
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SHAWNEE MISSION PUBLIC SCHOOLS—DISTRICT NO. 512

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Front Cover Photo: Tornado near Scottsbluff, Nebraska, June 27, 1955.
Taken by V. Pumphrey. Courtesy National Weather Service.
SELS Center, Kansas City, Missouri



In the March 1972 Report of the National Association of State Civil Defense Directors, I wrote: "Public safety and security are watch-words of civil defense. . . ." That same month I reported we had reached formal agreements with other Federal agencies for working with communities in preparedness for peacetime disasters. Such preparedness takes many forms. We at DCPA seek as many ways as possible to assist local efforts. One way is promoting safety from tornadoes.

Property damage and casualties caused by tornadoes are increasing as the Nation becomes more urbanized. Tornadoes have not become more frequent. It's just that as the population increases, construction keeps pace and covers more of the land surface.

Some communities are prepared for these severe storms, especially in areas where they are most frequent. An excellent example of preparedness—the Shawnee Mission School District's Tornado Shelter Plan—is presented in this report.

We can all learn from the experiences of others. That is why we compiled the details of how this suburban community has planned to safeguard its children. The plan also offers protection from fallout radiation, which could be a grave threat in case of nuclear attack.

John E. Davis

John E. Davis
Director
Defense Civil Preparedness Agency

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DISTRICT 512

DISTRICT NO. 512
SHAWNEE MISSION PUBLIC SCHOOLS

A school is made up of many things. . . blackboards and backboards. . . books and bands. . . lockers and lunchrooms and labs. . . a place for learning and growing, a place where we build for the future.

It can also be something more. . . a shelter to help safeguard that future. . . for our children and our communities.

Author Unknown

This booklet describes a school district in suburban Kansas City, Kansas, which provides that "something more" in many of its buildings.

Kansas and nearby Missouri are among the half-dozen States in middle-America having the greatest frequency of tornadoes of any region in the world. The chances of any particular location being struck by a tornado in the counties surrounding Kansas City are several times higher than in nearby States and are exceeded only in central Oklahoma and along the Texas-Oklahoma border.

A person's safety in an area struck by a tornado depends upon his nearness to the storm and the strength of the building he is in. Knowing what to do and where to seek safety may not be enough. Life and safety may depend upon resistance of the building to the extreme winds.

Providing for the safety of the relatively unresourceful child in school is a responsibility which transcends the daily learning activities. Tornadoes are one such threat to pupil safety in Kansas. In some districts school is dismissed when violent weather threatens. In others safety is sought in the strongest portions of the school buildings. Still others have designed and constructed tornado-resistant shelters as integrated parts of the school facilities.

The Shawnee Mission School District has followed the latter course of action. In general, the pattern followed by the district has been to provide tornado protection in as many schools as possible rather than randomly build a shelter as the opportunity appears. This district wide approach is the unique aspect examined in this booklet.

Shawnee Mission School District Number 512 was formed in 1970 through unification of 13 elementary school districts and the Shawnee Mission High School District in Johnson County, Kansas. In their planning for tornado safety, administrators and patrons of District No. 512 are the beneficiaries of decisions and actions taken independently by the elementary-school districts in earlier years as well as by similar earlier actions of the high-school district which resulted in tornado-resistant facilities in a number of schools.

The district presently operates 5 senior high schools, 10 junior high schools, and 50 elementary schools. Of these 65 schools, 37 have tornado shelters.

The district serves a population of 196,300 in an area of approximately 74 square miles. Total pupil enrollment in 1972-1973 was 44,578, including special education.

The map on page 3 indicates the general service area of the district in metropolitan Kansas City. The locations of schools are indicated in a large-scale map of the school district shown on pages 4 and 5. Those schools with tornado protection are identified as are the schools illustrated in this booklet.

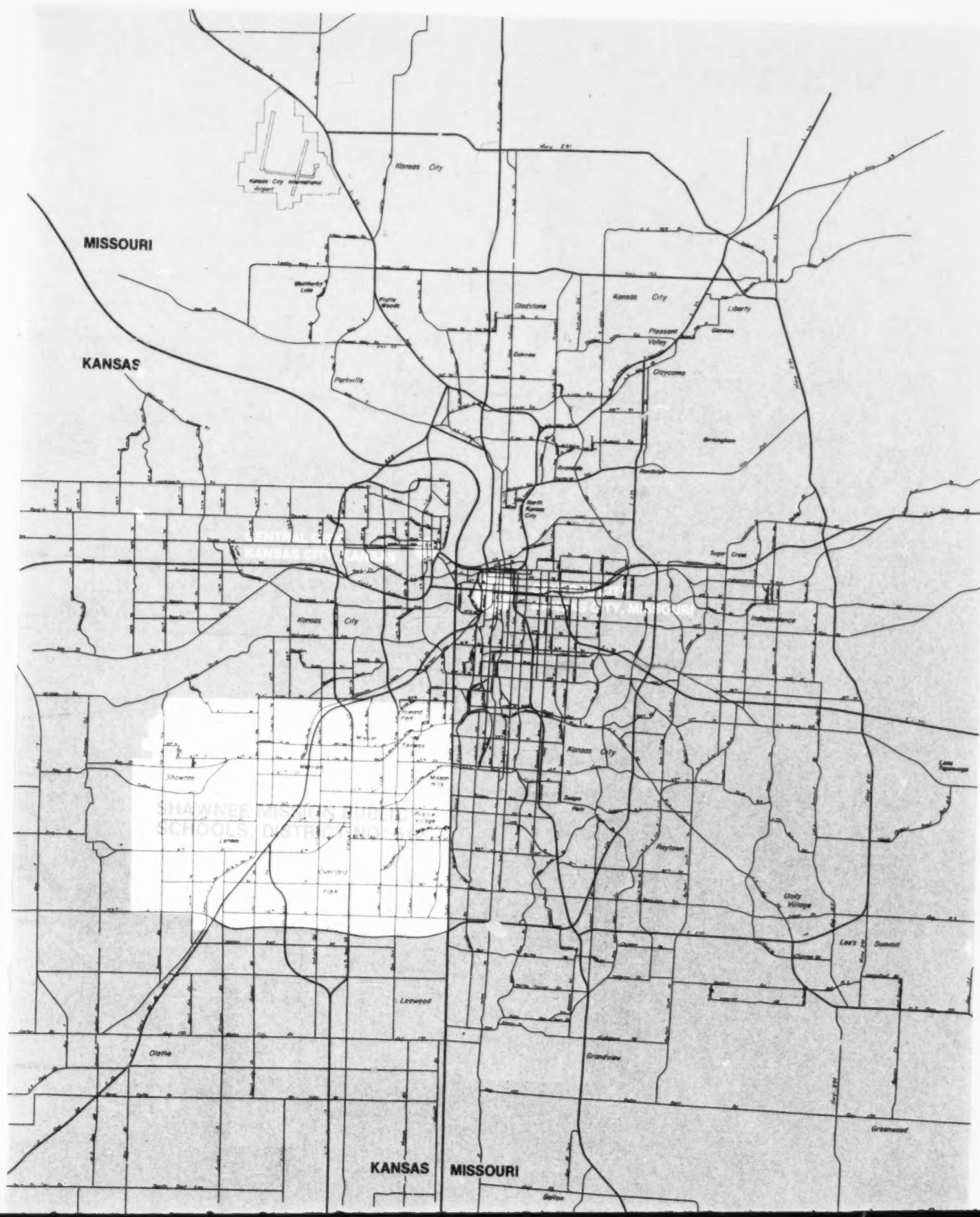
Former Overland Park Elementary School District No. 110, one of the elementary-school districts included in the unification, offers an especially interesting case study of tornado protection. Through a construction program commenced in 1966, District No. 110 developed tornado shelter in each of its 14 existing schools and required that tornado protection be designed into one new school. Thus, all schools of the former district provide tornado protection for all enrolled pupils and teaching staff.

The comprehensive planning undertaken by District No. 110 is unique in the Nation as an effort to provide for pupil safety from tornadoes. Voters recorded their support for tornado protection for the district's schools in a bonding referendum in May, 1966, and plans were drawn up and implemented in the ensuing 3 years.

The construction program called for upgrading and expanding a number of existing schools in District No. 110 to correct educational deficiencies. At the same time, tornado protection was developed in each of the 14 existing schools and in the design of one new school which was a part of the total construction program.

The educational needs of each existing school were unique due to wide disparity both in construction features and in space arrangements. Several of the schools were in need of library, music, art, or science areas; others needed indoor activity areas for the severe Kansas winter climate; two others needed no new instructional areas but because of their light construction appeared to offer no suitable tornado-resistant shelter; two schools appeared to offer both adequate instructional space and suitably rigid structures for tornado protection. Some of the existing buildings were slab-on-grade construction without basements; other schools had basements or were designed with two levels on sloping sites. Because of these wide-ranging situations, the solutions to the educational and safety requirements were equally wide-ranging.

Designs for all 15 schools of the Overland Park Elementary School District program and for



DISTRICT NO. 512

Shawnee Mission Public Schools



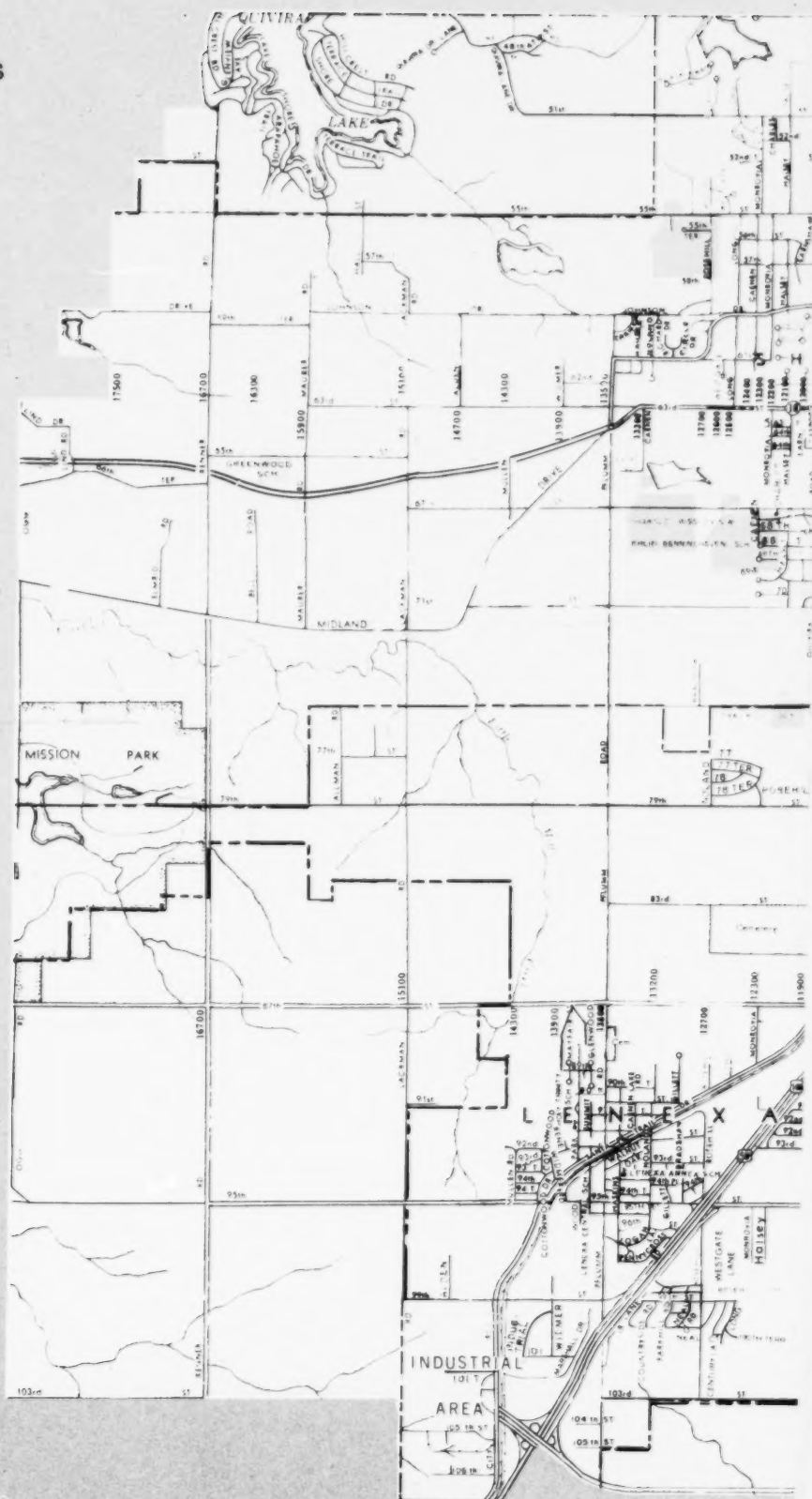
Schools with Tornado Protection,
illustrated in booklet.

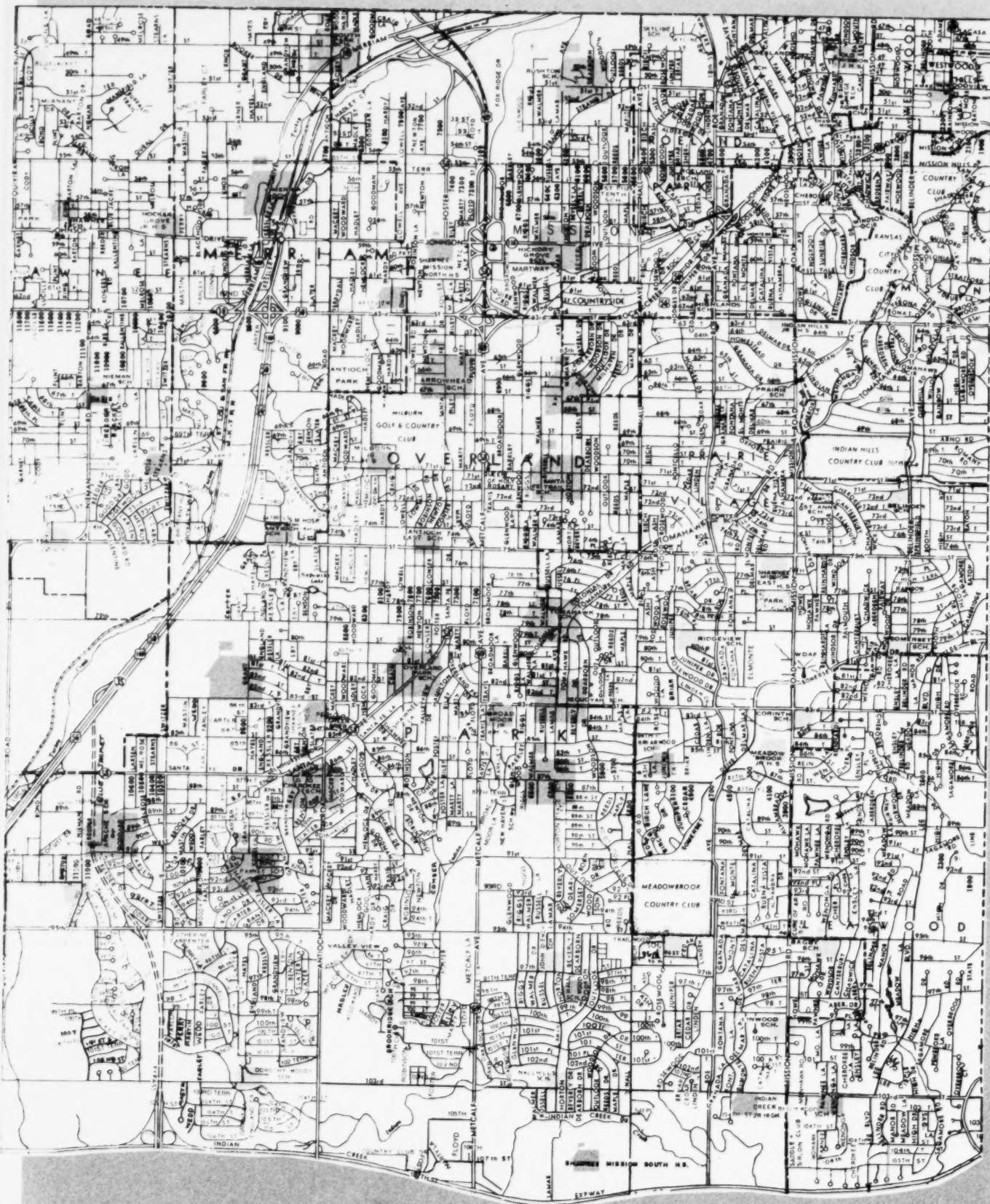


Schools with Tornado Protection,
not illustrated in booklet.



Schools without Tornado Protection,
not illustrated in booklet.





several other schools now a part of District No. 512 were prepared by the firm of Marshall & Brown, Architects and Engineers, with offices in Kansas City, Kansas, and Kansas City, Missouri. Results of their efforts, illustrated in later pages of this booklet, may be categorized in four distinct groups:

Addition of new instructional facilities with tornado protection included in belowground space.

Addition of new instructional facilities with tornado protection included in aboveground space.

Addition of new single-use, tornado-protected space.

Renovation of existing facilities to create tornado-protected areas.

Design criteria were established by the architects after considerable research into space needs and tornado-resistant design. The architects found that fallout radiation protection occurred as a spin-off benefit in most of the tornado-protected spaces. Consideration was given to space requirements for the shelter areas, their ventilation, the structural resistance to high winds and collapse of surrounding portions of the schools, and to penetration of airborne debris into the shelters. Emergency electrical power was provided in all by means of small, gasoline-driven generators.

The former Overland Park Elementary School District, while unique, was not the only district included in the unification which had schools with tornado protection. Shawnee Elementary School District No. 27 also had several schools designed with tornado shelter for pupils. Schools with tornado protection from District 27, District 110, and the Shawnee Mission High School District are illustrated in this booklet. Moreover, other architectural firms in the Kansas City area besides Marshall & Brown have participated in designing tornado shelters for schools. The work of only two firms are illustrated, however, because the example schools came from just 3 of the 14 former districts where these architectural firms were most actively engaged in school facilities design.

Whatever the reasons that tornado protection was created in schools of the former districts, Shawnee Mission School District No. 512 now places great value on the fact that past decisions and activities of the communities it serves have supported the idea that safety for their youth is expected in the schools which serve them.

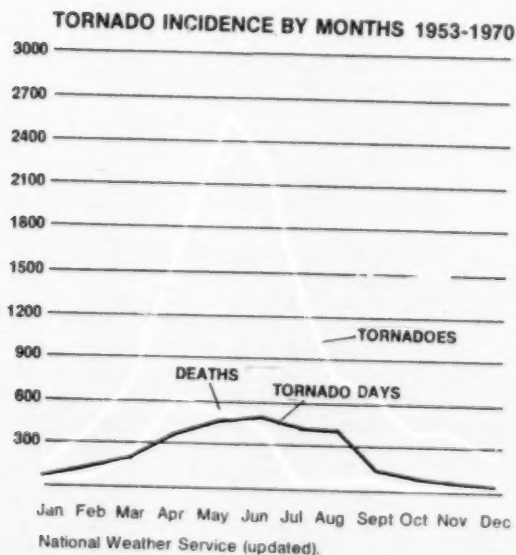
PHENOMENOLOGY

TORNADOES

Tornadoes are the most violent of all the winds of the world. They are severe local storms with cyclonic winds typically sweeping in a counterclockwise rotation about a funnel-like vortex. The extreme winds of this vortex are among the most destructive on earth as they move through populated, built-up areas.

Tornadoes occur in many regions of the world and have been reported in all of the 50 States. Formation of these storms is most frequent in the continental plains of North America, coincident with the mid-western States of Texas, Oklahoma, Kansas, Missouri, Nebraska, Iowa, and Illinois, but the southeastern States experience many as well. The region of tornado occurrence tends to shift with the seasons. While no season is free of the storms, reported tornadoes in the southeastern States tend to increase in the late winter and early spring months; whereas the largest number of reported tornadoes in the central plains States is in late spring. In early summer, the occurrences are greater in the upper midwestern States. This seasonal shift is associated with the global seasonal adjustments of prevailing winds and weather as colder northern hemisphere air collides with moisture-laden tropical air in an arc shifting from southwest to northeast from early spring through early summer.

The probability that a specific location will be struck by a tornado in any year is small. For example, the probability of a tornado striking a given building in the area most frequently subject to tornadoes is 0.0363, or about once in 250 years. The chances in other areas of the Nation are even less, approaching zero in some western States. However, the risk always is present. Mathematical probability is but a tool for prediction and provides only a statistical basis for analysis. Actual occurrences in specific locations provide numerous exceptions. It has been noted, for example, that tornadoes have struck Oklahoma City nearly 30 times since 1892.



Tornadoes may occur at any time during the day or night but form most frequently during the warmest hours of the day from late afternoon into early evening. 82 percent of the total occurrences is between noon and midnight; 23 percent is between 4 and 6 p.m.

The "average" tornado rotates in a counterclockwise direction in the northern hemisphere, moves at about 45 m.p.h. in a northeasterly path, and impacts upon an area about 475 feet wide and 15 miles in length during a time span of about 20 minutes. However, the "average" tornado rarely occurs. Tornadoes rotating clockwise have been reported—although infrequently; speed of travel is related to the "mother" tornado cloud, and reports of speed vary from 15 m.p.h. to 60 m.p.h. The path of destruction may be a few hundred yards or several hundred miles long and less than 100 feet or over a mile in width. Some tornado vortices never touch the ground and may be very short-lived, or the tornado may drop to touch the ground, rise and drop again in a hopscotch manner.

Although warning systems advising of tornado threats have reached a high level of sophistication, the physical factors associated with tornado formation, the localized nature of the storm, and the short time of occurrence make protective action difficult and somewhat limited. The usually short time between warning and actual impact of a tornado upon an area allows for little more protective action than to seek shelter or cover in some reasonably protected area. Tornado watches for specific geographic areas, released by the National Severe Storms Forecast Center in Kansas City, Missouri, and broadcast to the public by radio and television, are the first alert that meteorological conditions are right for the spawning of tornadoes. Tornado warnings are broadcast when an actual sighting of a tornado has been reported. Thus, there is some chance to mitigate the effects of these storms on the lives and safety of people. Except with extremely rigid construction, there is little chance to insure the durability of buildings by preventive action. Steps to mitigate property losses must be taken before a tornado alert, preferably at the time of building design and construction.

There is some disagreement and considerable uncertainty about maximum wind velocities associated with tornadoes. Measuring devices most often are not at the locations of the storms, and those that are rarely survive the wind pressures. Current estimates place the maximum velocity at about 300 m.p.h., but higher and lower values have been argued with convincing data. However, even a wind velocity of 200 m.p.h. will result in a wind pressure of 102.4 lb. per sq. ft. of surface area—a loading above that which most buildings are designed to resist. Clearly, normal construction practices must be upgraded to resist such forces.

Another characteristic of the tornado having serious implications on building response is the partial vacuum in the core of the funnel. The resulting pressure differential between ambient air within a building and the partial vacuum created by the moving vortex can result in "explosive" loadings of even greater magnitude than those produced by the wind pressure.

Still another hazard in the area impacted by these extreme winds is the flying missile, or airborne debris, carried by the winds. Gravel from roofs or ground, debris from buildings torn apart, or components from localized building failure create a serious hazard to people and cause uncounted broken windows and damaged walls.

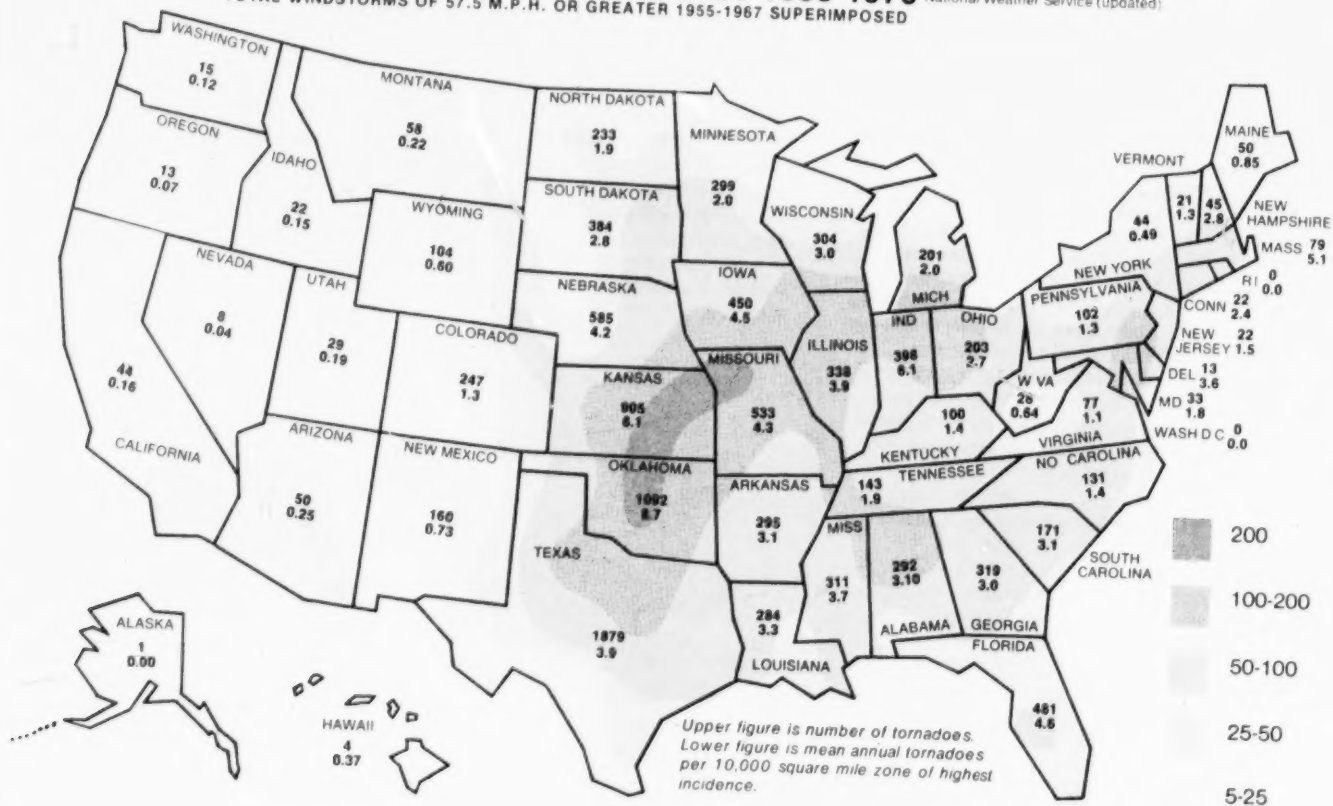
If the safety of building occupants is to be insured, and if the amount of property damage caused by tornadoes is to be reduced, greater attention to building rigidity and securely fastened components must be provided. Total resistance probably is not feasible for buildings which might be subjected to tornadic forces of the magnitudes cited above. Property loss often will be an acceptable alternative; whereas danger to people is not acceptable. Practical considerations of construction cost and appearance make tornado shelters attractive as a third alternative. It is possible to provide safety for occupants in a small portion of a building in lieu of constructing the entire building to withstand the tornado. Thus, the objectives of safety for occupants and of reasonable construction cost and appearance can be satisfied simultaneously for buildings which might be subjected to the extreme loadings caused by tornadoes.

The concept of a dual-purpose tornado shelter was followed by the architects of the schools shown in this booklet. Although most of the schools would not be expected to come through a tornado undamaged, each offers an area of safety for the students—from building collapse, from pressure differential loadings, and from flying debris. These schools have gained their protection in a variety of ways, but all protected areas were developed to resist the basic forces described above.

Clearly, it is possible to provide for human safety in schools constructed in regions frequently subjected to tornadoes. The tornado-resistant area of the schoolhouse offers a solution to the several unique characteristics of these storms—their unpredictable occurrence, the short warning time usually given, and their extreme forces. The tornado shelter does not do much to mitigate property damage, however. That is another kind of problem. But it also can be solved through design once the basic phenomena of the storm and the vulnerabilities of building components are understood.

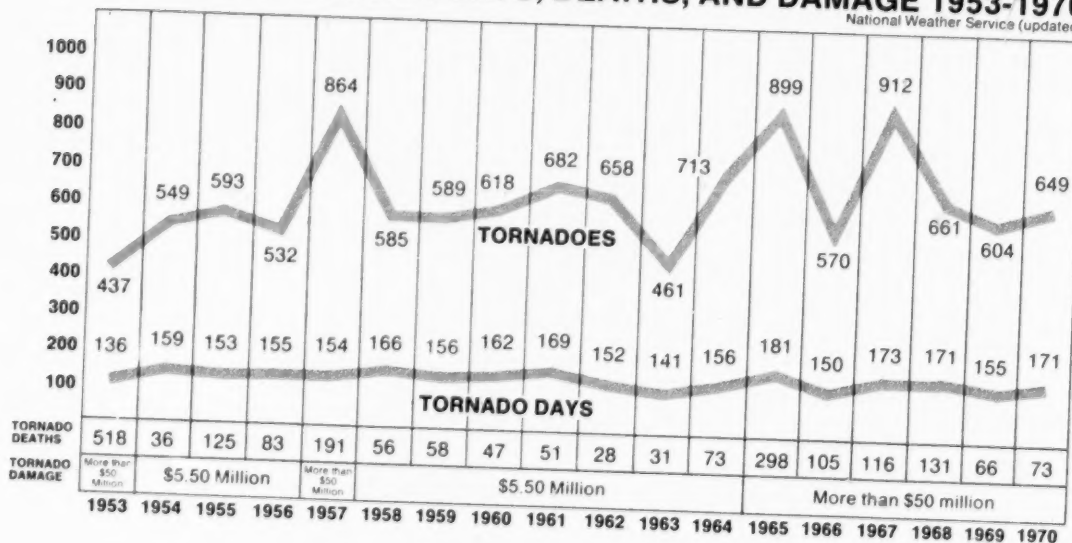
TORNADO INCIDENCE BY STATES 1953-1970

TOTAL WINDSTORMS OF 57.5 M.P.H. OR GREATER 1955-1967 SUPERIMPOSED National Weather Service (updated)



TORNADOES, TORNADO DAYS, DEATHS, AND DAMAGE 1953-1970

National Weather Service (updated)



FALLOUT

Shelters which provide protection against nuclear explosions, including fallout radiation, and tornado shelters have several common aspects. Foremost is their purpose—that of providing for the safety of people.

There are other common aspects which less frequently are known or understood. For example, the strong construction required to provide for human safety from tornadoes often will offer the necessary protection from radioactive fallout. The space requirements of the two kinds of shelters are based upon an area allowance per occupant. However, the unit area allowance for tornado shelters usually is smaller than for fallout shelters due to the shorter staytime. Ventilation needs for both types of shelters are established from occupancy but, again, tornado shelter ventilation requirements are lower because of the shorter use time and associated smaller heat gain.

A significant aspect of the schools illustrated in this booklet is that the designs for tornado protection in most cases also meet the requirements for fallout radiation protection. A comparison of design considerations for the two hazards is provided on page 11.

There also are differences in the two hazards—tornadoes and fallout radiation—just as there are common aspects. One major difference is that fallout radiation would be an areawide, indeed likely a nationwide, occurrence.

Another difference is the length of time that the fallout hazard would persist in contrast to the tornado hazard. The tornado watch and warning times combined rarely exceed a few hours; whereas the fallout radiation hazard could persist for a number of days. Thus, the staytime in a fallout shelter is from 48 hours up to two-weeks.

Radioactive fallout is produced by surface nuclear detonations. Ground-level nuclear explosions produce a residue which falls to earth as a widespread blanket of tiny radioactive particles. Gamma radiation from fallout can cause sickness or death to unprotected persons. The pattern and extent of fallout is unpredictable due to its dependency upon prevailing winds, moisture content of the air, size of weapon, height of detonation, and other factors.

Fallout shelter, like tornado shelter, is a concept of protection in which buildings provide safety for people. Protection Factor (PF) is the measure of radiation protection afforded by a sheltered location. It expresses a relationship between amounts of radiation that would be received by an unprotected person and by a person inside a shelter.

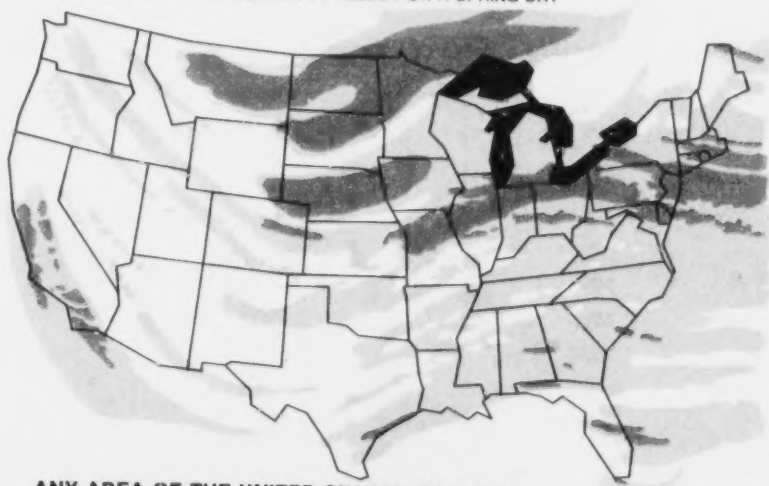
High radiation protection factors are achieved through manipulation of roof and wall planes of a building—called "geometry shielding" when the path of the radiation is affected, and called "barrier shielding" when the mass of the wall or roof material is increased.

Every building provides some protection from fallout radiation. Some buildings offer better shelter than others because of the way they are designed or the construction materials used. Buildings with basements offer inherently good radiation shielding. Multi-storied buildings and those with reinforced concrete floors and roofs also offer better-than-average shielding. However, even one-story, slab-on-grade buildings sometimes can be modified to provide acceptable shielding without excessive cost or loss of function. Through careful design, shelter in buildings can be created, inherent shielding can be improved, and weak points can be avoided.

DISTRIBUTION OF RADIOACTIVE FALLOUT ON A FALL DAY



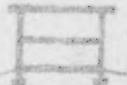
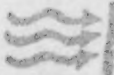
DISTRIBUTION OF RADIOACTIVE FALLOUT ON A SPRING DAY



ANY AREA OF THE UNITED STATES COULD BE SUBJECTED TO RADIOACTIVE FALLOUT

Distribution patterns above are based upon an assumed attack situation and given meteorological conditions of two different days.

A COMPARISON OF DESIGN CONSIDERATIONS

		TORNADOES	FALLOUT RADIATION
	EXTENT OF HAZARD	Localized	Nationwide
	WARNING TIME	A few minutes to a few hours	Up to several hours
	HAZARD TO PEOPLE	Serious to fatal	May be fatal
	HAZARD TO BUILDINGS	Moderate to severe	None
	STAY TIME IN SHELTER	A few hours or less	Several days to 2 weeks
	SPACE REQUIREMENTS	Allow 4 to 7 sq. ft. per person	Allow 10 sq. ft. per person
	VENTILATION OF SHELTER	Recommended	Required—varies with geographic area
	WIND VELOCITY PRESSURE	Up to 300 m.p.h., or 230 p.s.f.	None
	SHIELDING	Structural rigidity only	Mass thickness and geometry
	PRESSURE DIFFERENTIAL	Venting recommended	None
	ENCLOSURE	Baffling from flying debris	Baffling from sight-line radiation paths

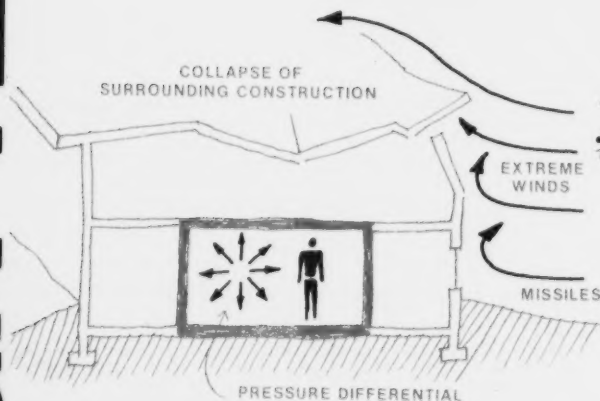
DESIGN TECHNIQUES

Tornado protection involves two fundamental concerns—protection of people and mitigation of property damage. Safety for building occupants is dependent upon rigidity of the structural system which encloses the shelter. Resistance to the following effects is essential:

- Extreme Winds — structural collapse or translation
- Pressure Differential — internal explosive force
- Collapse — surrounding building failures
- Flying Debris — airborne missiles

Mitigation of property damage also is possible through design. Aspects of the complete building to be considered include the following:

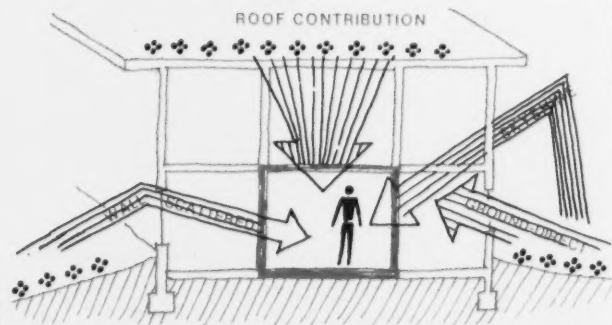
- Structural System — sufficient rigidity of the complete structural system.
- Component Rigidity — adequate anchorage of component assemblies to building—doors, overhangs, parapets, etc.
- Flying Debris — components torn from the building, from other buildings, and ground missiles.
- Water Damage — internal damage by rain accompanying the tornado when roofs, windows, and doors fail.



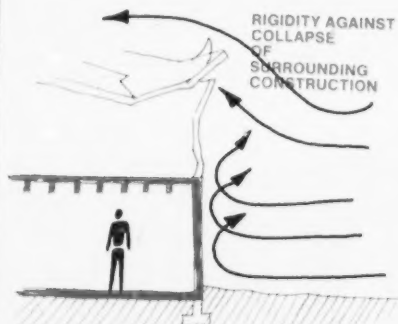
Fallout radiation protection is for the safety of people. Safety is achieved by minimizing the amount of lethal radiation entering the shelter from fallout radiation fields on the outside. Gamma radiation enters a building from two sources:

- Roof Contribution — radiation emitted by radioactive particles on overhead surfaces.
- Ground Contribution — radiation emitted by radioactive particles which accumulate on ground surfaces. The ground contribution is further categorized as ground-direct, wall-scattered, and skyshine.

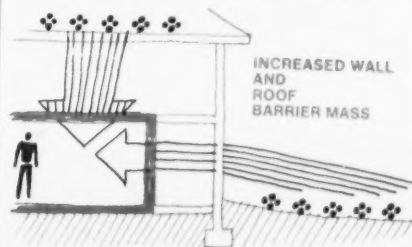
Fallout protection may be enhanced for a shelter location by any one or more of several design techniques. Increased barrier mass through judicious selection of construction materials, arrangement of interior spaces, placement of windows or other openings, and site features such as slope, earth berms, and retaining walls are among the many techniques which have been developed for improving the radiation shielding qualities of buildings.



Economically, it appears infeasible to design all buildings to resist a direct hit by a tornado. In such cases a tornado-protected space within a building must be designed to withstand not only the tornadic winds but also the possible collapse of portions of the building or adjacent construction.

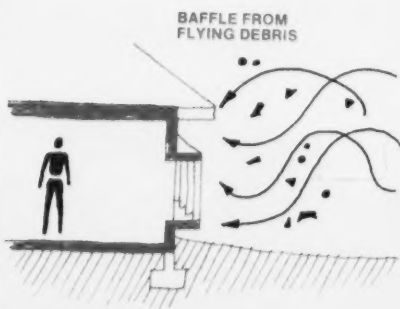


Overhead radiation contribution may be reduced by increasing the overhead mass, either at the roof plane or at intermediate floors, or by increasing the distance between the contaminated roof plane and the shelter space. Ground contribution may be reduced by increasing the exterior wall mass, by reducing the window areas, altering their locations, or by placing interior partitions between the shelter and the radiation source. Interior partitions also may help to reduce the overhead contribution.

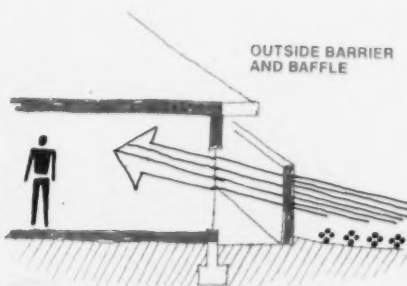


A space rigidly designed to resist tornado-induced loadings probably is enclosed with walls and roof of increased thickness for structural resistance—more mass. Reciprocally, a space designed to offer radiation protection most likely is enclosed with walls and roof of increased mass—though not for structural reasons. Thus, no matter which is the initial concern, resistance to both hazards will be enhanced.

Tornadic winds can hurl objects, large and small, with tremendous speed. These flying missiles are an extremely serious hazard to human safety as well as to building rigidity. Baffled entrances and other openings into the shelter are essential to the safety of human occupants.

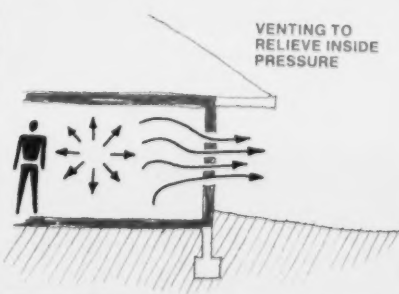


Barriers placed outside the building such as planting boxes, earth berms, and screen walls offer much the same shielding as barriers within the building. Ground-source radiation can be attenuated effectively by judiciously placing these kinds of barriers between the shelter and the principal radiation source field.

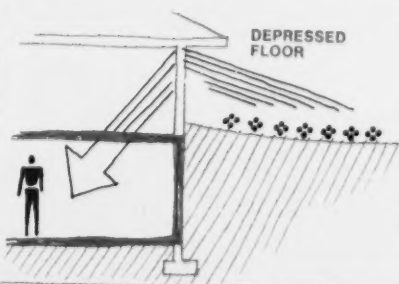


Baffling of openings to resist penetration of wind-blown debris is accomplished in ways similar to placement of outside barriers to reduce sight-line entry of radiation in a shelter space. Although the objectives are different, the means may be the same, and the result will be enhanced resistance to both hazards.

The vortex of a tornado creates a partial vacuum. When the vortex passes over a building, the resulting force is outward on the walls and roof. Depending upon the pressure gradient, this force may exceed the forces of the tornadic winds. Venting, which allows release of air pressure from within the space, is one way to relieve the outward loading on the structure.



Ground-direct radiation can be eliminated by dropping the shelter below the ground plane (a radiation source). Fully or partially depressed floor levels and basements offer nearly comparable shielding effectiveness provided the overhead shielding is suitable. Safety from tornado effects such as wind-blown debris also is evident. The shelter problems for both hazards thereby are limited to the overhead construction—its mass and structural rigidity.



A basement space often offers inherently good radiation shielding and tornado protection.

Some features of design which enhance resistance to effects induced by one hazard of the environment may not have parallel benefits of resistance to other hazards. Venting is unique to tornado effects.

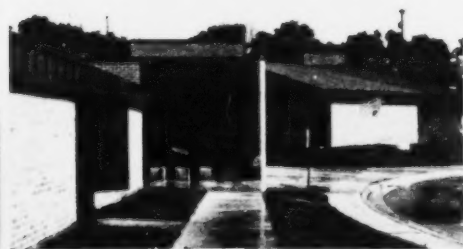
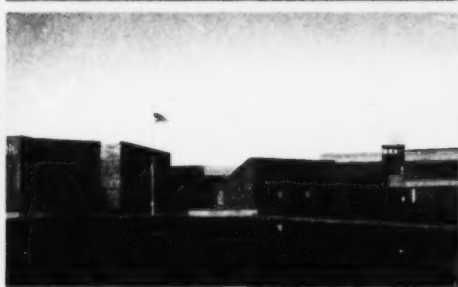
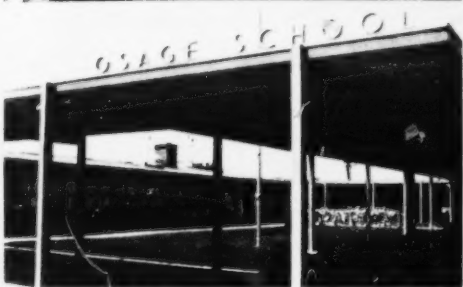
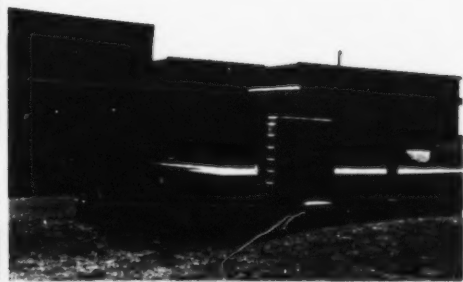
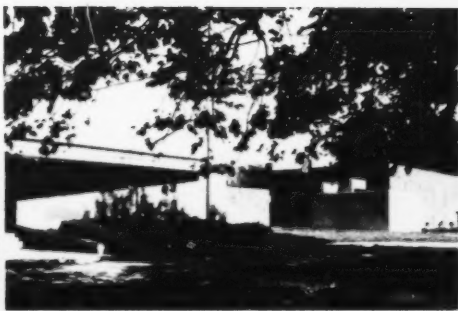


Photo: Paul S. Kivett, Architectural Photography

Photo: Paul S. Kivett, Architectural Photography

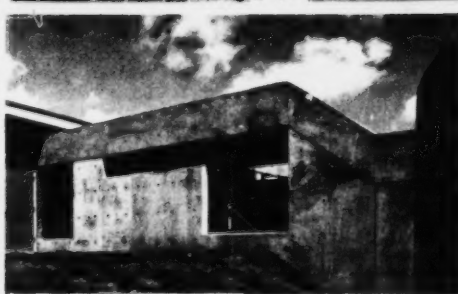
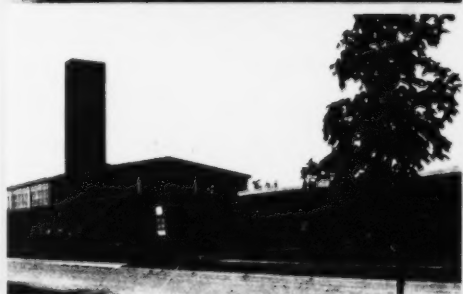
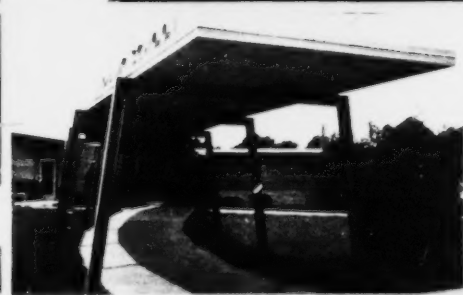
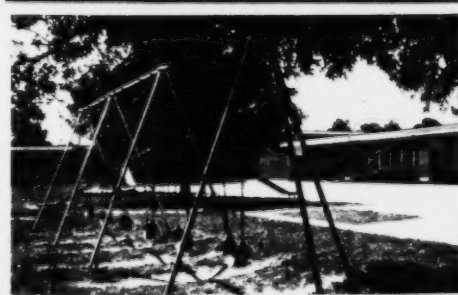
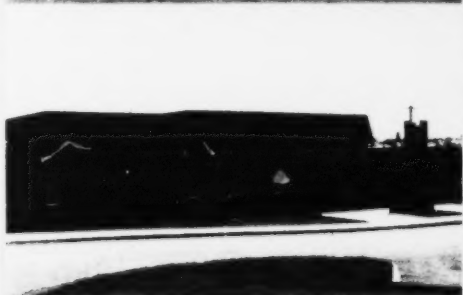
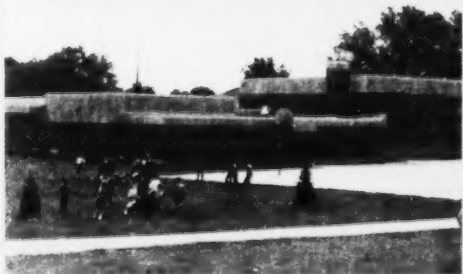


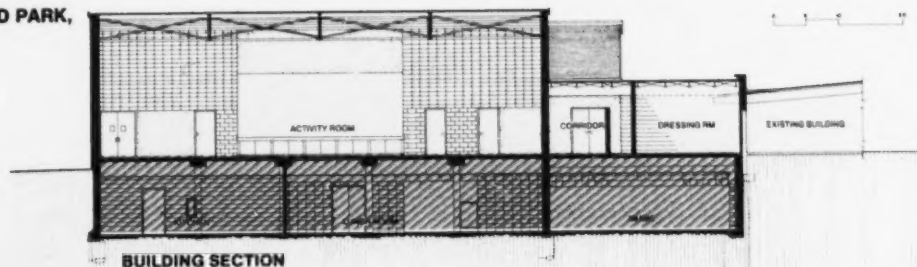
Photo: Paul S. Kivett, Architectural Photography



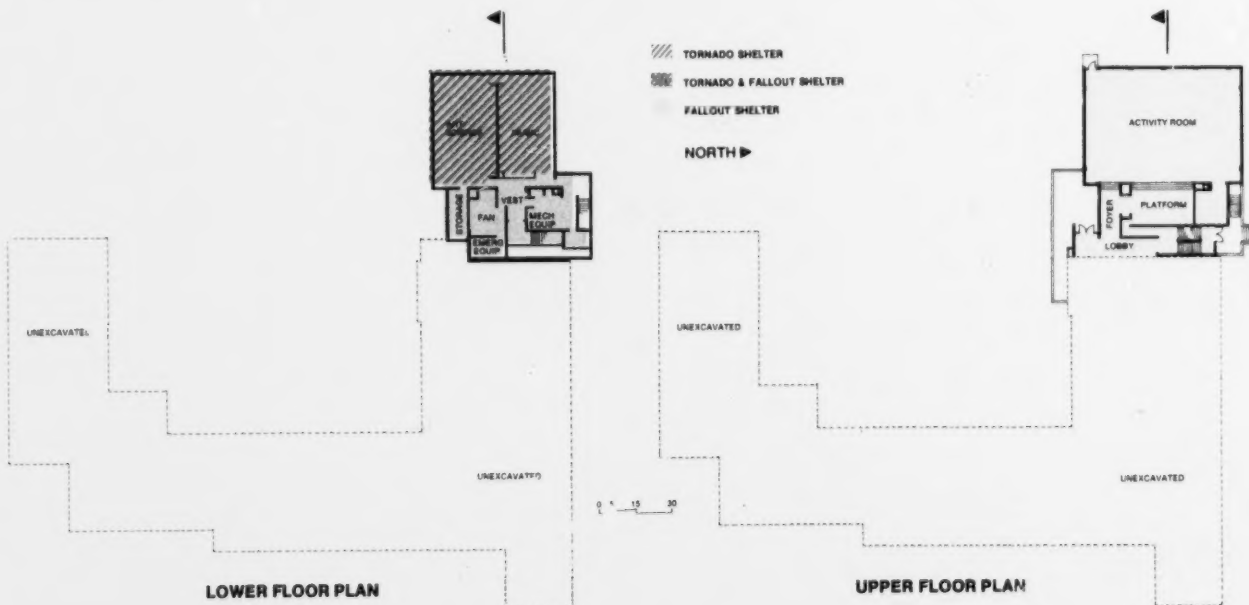
THE SCHOOLS

CHEROKEE

**CHEROKEE
ELEMENTARY
SCHOOL
OVERLAND PARK,
KANSAS**



An activity room, kindergarten, lunch room, kitchen, and music room were added to this finger-plan schoolhouse as part of former District No. 110's educational facilities upgrading program. These new facilities were designed into a two-story building. Tornado protection and fallout radiation protection were achieved by placing the lower floor (ground floor) below grade and by means of reinforced-concrete construction of the lower floor. The 6-inch slab-and-beam suspended floor was sized to resist collapse of the steel-framed upper level should the building be struck by a tornado. Due to its favorable location and heavy construction mass, the ground floor offers both tornado and fallout radiation protection. A 10-KW generator provides emergency power for ventilation and lighting in the shelter.



K-R

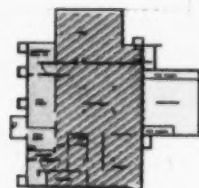
Enrollment: 200
Area of Addition: 10,952 sq. ft.
Cost of Addition: \$208,589.39
Shelter Location: Music and Art-Science Rooms—Lower Floor
Cost of Shelter: \$20,000.00 (estimated) or \$1.83/sq. ft.

Tornado Shelter	Fallout Shelter
2,350 sq. ft.	3,858 sq. ft.
335 persons	335 persons
(7 sq. ft./person)	

LOWER FLOOR PLAN

0 10 20 30

Addition by
Marshall & Brown, Architects & Engineers
Kansas City, Kansas



Tornado Shelter
6,125 sq. ft.*
750 persons
(7 sq. ft./person)

Fallout Shelter
6,840 sq. ft.*
590 persons
(includes 65 persons
in existing space)

/// TORNADO SHELTER
■ TORNADO & FALLOUT SHELTER
□ FALLOUT SHELTER

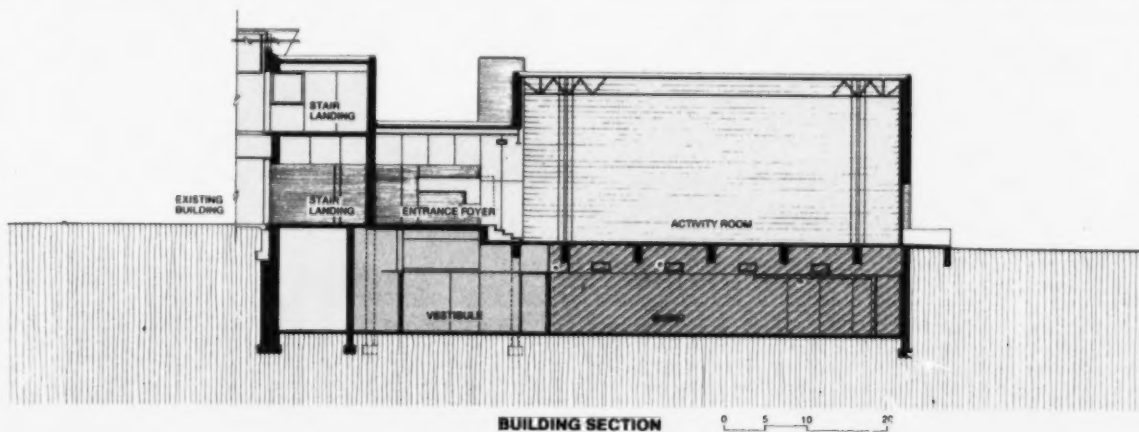
*Areas are gross square feet unless otherwise noted.

UPPER FLOOR PLAN

0 10 20 30

NORTH

K-6
Enrollment: 646
Area of Addition: 14,426 sq. ft.*
Cost of Addition: \$246,767.00
Shelter Location: Ground Floor of Addition
Cost of Shelter: \$25,000.00 (estimated) or \$1.73/sq. ft.



BUILDING SECTION

OSAGE

OSAGE
ELEMENTARY
SCHOOL
OVERLAND
PARK,
KANSAS



The Osage Elementary School was constructed in three phases. The east wing and south-wing cafeteria were completed in the late 1950's. A classroom wing was added on the north in 1960. An extension of the north wing was completed in 1968. The most recent addition included an activity room and art-science and music rooms in a two-story structure. A sloping site allowed connection of the activity room to the existing structure at grade (first floor of the existing classroom wing) and lower-level music and art-science rooms below ground. This lower-level space also doubles as a tornado shelter and fallout shelter. 5-inch slab-and-beam construction of reinforced concrete for the floor of the activity room provides safety from tornado-induced forces, including possible collapse of steel-framed upper-story construction. A 15-KW generator provides emergency power for ventilation and lighting in the shelter area.

RUSHTON

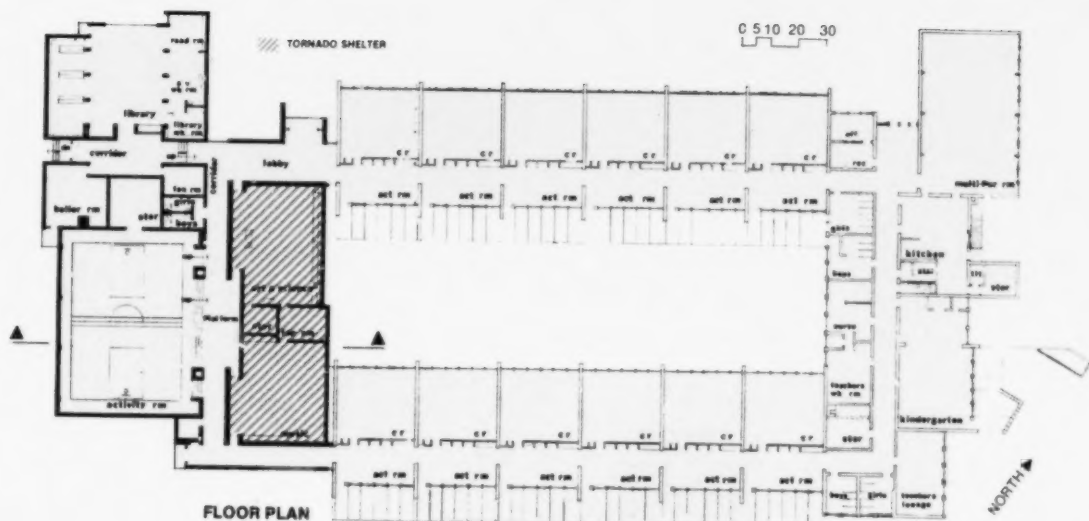
RUSHTON ELEMENTARY SCHOOL MISSION, KANSAS

Tornado Shelter
2,194 sq. ft.
400 persons
(5 sq. ft./person)

Fallout Shelter
40 persons in existing
building.
New construction—less
than DCPA standards—
200 persons.

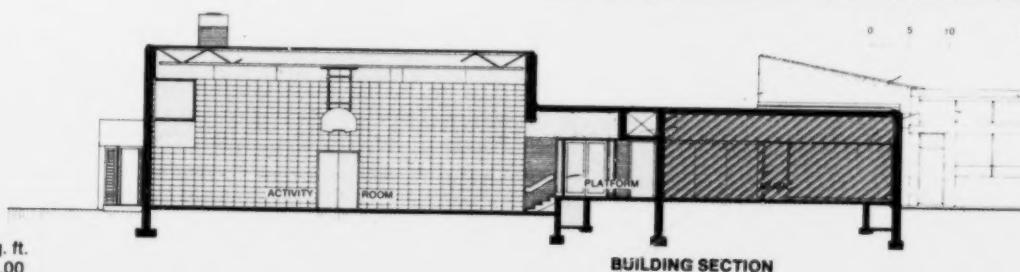
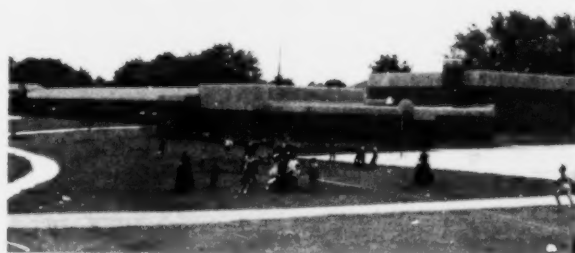
Addition by
Marshall & Brown,
Architects & Engineers
Kansas City, Kansas

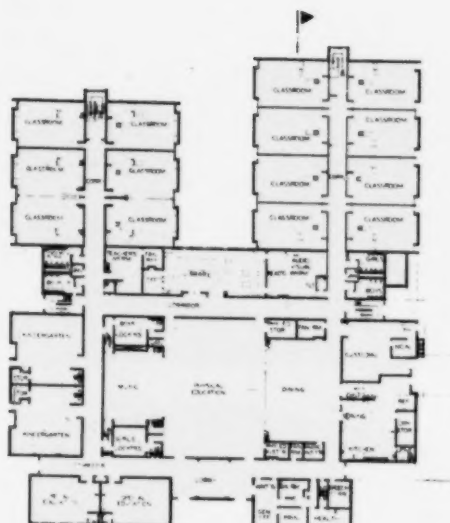
K-6
Enrollment: 331
Area of Addition: 12,890 sq. ft.
Cost of Addition: \$250,901.00
Shelter Location: Music Room
Cost of Shelter: \$35,000.00 (estimated) or \$2.72/sq. ft.



A library, activity room, music room, and art-science room were added in a one-story extension to this existing finger-plan schoolhouse in former District No. 110's upgrading program. An enclosed, planted court was created by positioning the addition so that it stretches across the ends of two parallel wings of the existing finger plan. A dropped floor level in the activity room accommodates the site which slopes downward from north to south. Exterior appearance of the addition is a combination of exposed reinforced concrete and brick. Deep concrete facias are features of the exposed concrete frame.

Tornado shelter was designed into a core space which is used daily for music and art-science instruction. Necessary protection was achieved with 12-inch concrete walls around the designated shelter area and with a 4½-inch slab-and-beam roof system just over the shelter area. Steel framing is used for other parts of the addition. Doors into the teaching areas, which double as tornado shelter, are recessed and positioned to provide baffling. A mechanical equipment room within the shelter area houses an emergency generator and ventilation fans. Spring-loaded louvers in the mechanical equipment space allow venting for pressure differential that might result from a passing tornado. This tornado shelter is one of a very small number in former Overland Park District No. 110 which does not provide fallout radiation protection meeting recommended DCPA standards. However, it does provide significant fallout radiation protection and could be the best shelter in the neighborhood. An additional one to two inches of concrete on the roof would provide shielding meeting DCPA standards.

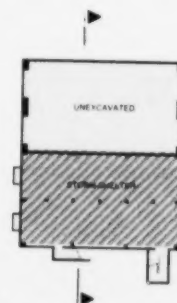




FIRST FLOOR PLAN

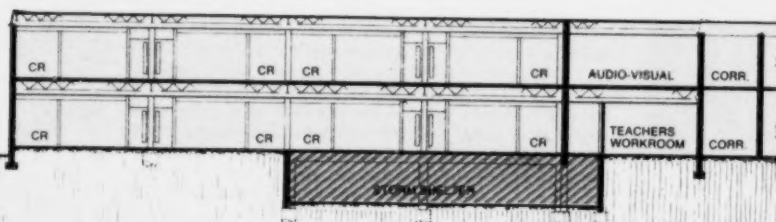


GROUND FLOOR PLAN



LOWER FLOOR PLAN

BUILDING SECTION



The original Pawnee School and a classroom-wing addition were constructed just two years apart. Initial construction was completed in 1967; the addition was completed in 1969 when 16 classrooms were added in a two-story addition. Because the new wing was planned when the original facility was designed and both were by the same architectural firm, construction materials and appearance are matched. Indeed, the phased construction is not at all evident. A tornado shelter was added to the addition as a basement-level space in a bid alternate. The alternate was accepted. The shelter-cost figure below is the bid alternate and is for the entire cost of the basement shelter. Protection was gained largely through the belowground location. A 6-inch concrete first-floor slab provided the needed overhead protection and was sized principally to resist collapse of upper floors. Emergency ventilation and lighting for the shelter are powered by a 7.5-KW generator. Fallout radiation protection was gained simultaneously with tornado protection in this addition.

K-6

Enrollment: 828
Area of Addition: 23,780 sq. ft.
Cost of Addition: \$325,268.00
Shelter Location: Basement of Southwest Classroom Wing
Cost of Shelter: \$47,787.00 (bid alternate) or \$2.01/sq. ft.

Original Building & Addition by
Marshall & Brown, Architects & Engineers
Kansas City, Kansas

PAWNEE

**PAWNEE
ELEMENTARY SCHOOL
OVERLAND PARK,
KANSAS**

Tornado Shelter
4,257 sq. ft.—net
851 persons
(5 sq. ft./person)

Fallout Shelter
4,257 sq. ft.—net
565 persons
(Includes 140 persons
in initial construction)



SANTA FE

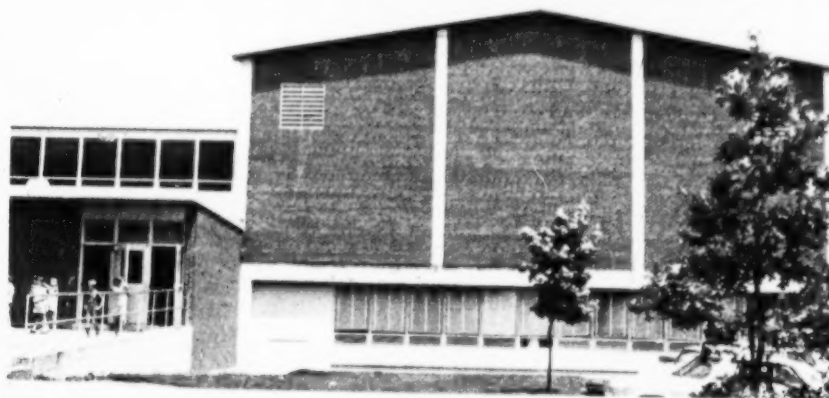
SANTA FE TRAIL ELEMENTARY SCHOOL OVERLAND PARK, KANSAS

Santa Fe Trail Elementary School is one of two schoolhouses of former District No. 110 to which no new educational space was added in the upgrading program of the late 1960's. Moreover, an examination of the building indicated that adequate tornado shelter already existed in ground-floor locker room and storage areas under an activity room on the first floor. Fallout shelter also had been identified in the same general area prior to the tornado protection analysis but only about one-half of the tornado shelter meets DCPA standards for fallout radiation protection. However, all the area provided significant fallout radiation protection. Because of these favorable findings—the lack of need for new educational facilities and the presence of acceptable tornado shelter—no modifications or additions were made to this schoolhouse.

K-6
Enrollment: 507
Shelter Location: Ground-Floor Dressing Rooms & Storage

Shelter Analysis by
Marshall & Brown, Architects & Engineers
Kansas City, Kansas

Tornado Shelter	Fallout Shelter
3,800 sq. ft.—net	1,900 sq. ft.—net
760 persons	190 persons
(5 sq. ft./person)	



K-6
Enrollment: 449
Shelter Location: Ground-Floor Cafeteria

Alterations by
Marshall & Brown, Architects & Engineers
Kansas City, Kansas



This schoolhouse is the other of two schools of former District No. 110 for which tornado protection was developed or found in existing construction. New facilities were not needed for Hickory Grove Elementary School so much as was upgrading of existing facilities. Hickory Grove Elementary School is an old school, the oldest of former District No. 110, and has been expanded several times in small increments. Educational rehabilitation of existing space was deemed more essential than new construction. An examination of existing space also revealed the presence of acceptable tornado and fallout radiation protection. The protection was inherent in original construction. Fallout-protected areas are in adjacent or nearby equipment rooms and storage space. The space selected for the tornado shelter does not meet fallout-shelter shielding standards. In this case, the fallout-protected areas provide tornado protection but not the other way around.

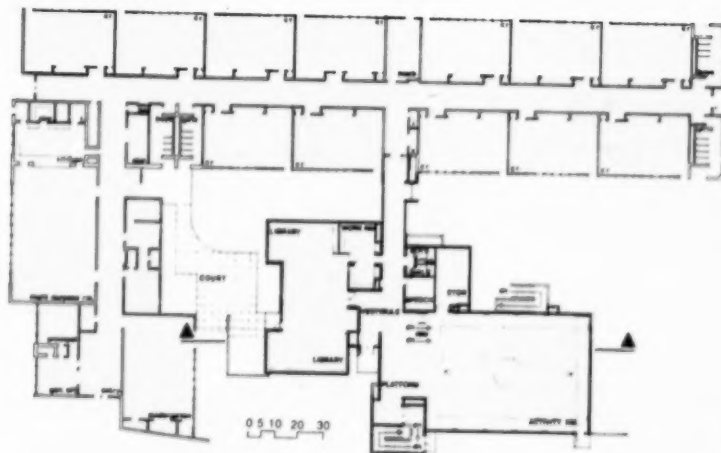
The cafeteria/tornado shelter opens to grade on the south and is set into the sloping ground on the north. Modifications to create an acceptable tornado shelter comprised only emergency ventilation and baffling of a few windows along the exposed south wall. The structural integrity of the existing concrete one-way, ribbed-joist floor system was deemed suitable against tornado-induced forces. A few windows were closed with matching ashlar stonework, and a spring-loaded louver venting system for relieving air pressure (tornado-induced pressure differential) in the south wall was baffled against wind-blown debris by a concrete pier.

Tornado Shelter	Fallout Shelter
1,000 persons	7,394 sq. ft.
(6 sq. ft./person)	515 persons

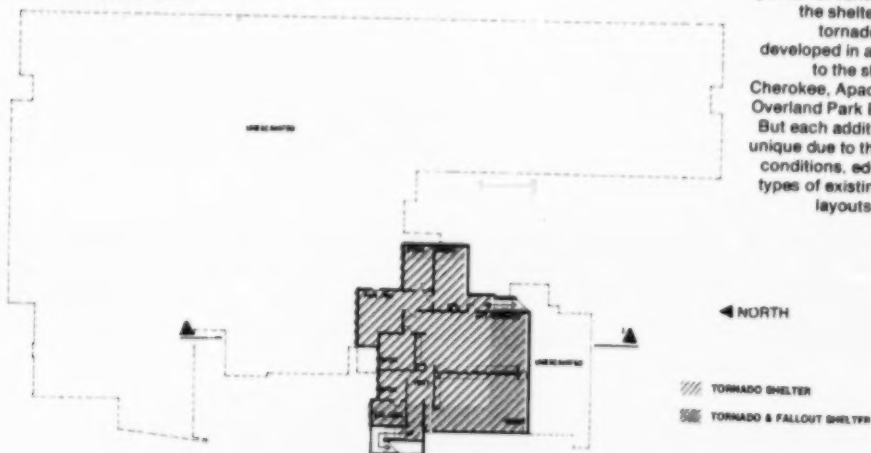
HICKORY

**HICKORY
GROVE
ELEMENTARY
SCHOOL
MISSION,
KANSAS**

UPPER FLOOR PLAN

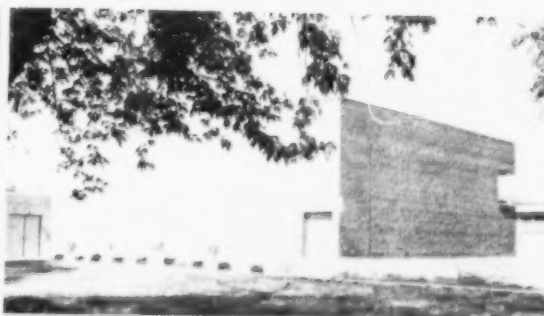


LOWER FLOOR PLAN



ARROWHEAD ELEMENTARY SCHOOL OVERLAND PARK, KANSAS

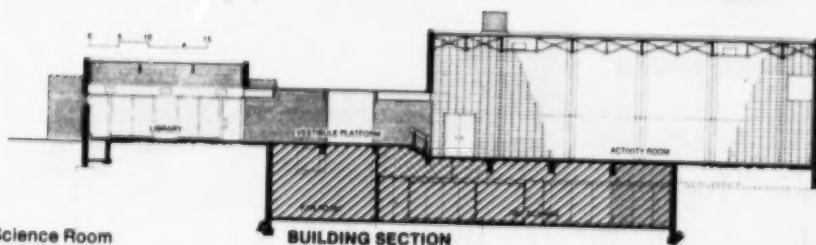
Addition of an activity room, library, music room, and art-science room was made to the existing one-story, finger-plan Arrowhead Elementary School. The addition was designed as a separate two-level building linked to the existing schoolhouse by means of an enclosed corridor. An activity room and a library were placed at the first-floor level which coincides more or less with finished grade. The music room and art-science room were positioned at a lower level which is fully below ground. Tornado protection and fallout radiation protection were created in the basement-level classrooms. A 5-inch concrete slab-and-beam floor system provides overhead protection. A 15-KW generator provides emergency power for ventilation and lighting of the shelter. Conceptually, this tornado/fallout shelter was developed in a manner very similar to the shelter for the Osage, Cherokee, Apache, Tomahawk, and Overland Park Elementary Schools. But each addition is architecturally unique due to the differences in site conditions, educational programs, types of existing construction, and layouts of existing schools.



Addition by
Marshall & Brown, Architects & Engineers
Kansas City, Kansas

Tornado Shelter	Fallout Shelter
3,564 sq. ft.	1,826 sq. ft.
509 persons	155 persons
(7 sq. ft./person)	(includes 75 persons in existing space)

K-6
Enrollment: 298
Area of Addition: 12,633 sq. ft.
Cost of Addition: \$ 235,946.24
Shelter Location: Lower-Level Music Room & Art-Science Room
Cost of Shelter: \$20,000.00 (estimated) or \$1.58/sq. ft.



ARROWHEAD

NORTHWEST

**SHAWNEE MISSION
NORTHWEST
HIGH SCHOOL
SHAWNEE, KANSAS**

This new senior high school for the former Shawnee Mission High School District was designed by the same architectural firm that completed the entire educational facilities upgrading and tornado-shelter programs for former Overland Park Elementary School District No. 110. All of these schools now are part of Unified District No. 512. The Shawnee Mission Northwest High School also was designed with a tornado shelter at the request of the district, and the tornado-shelter area doubles as a fallout shelter.

Northwest High School contains several unique architectural features which add to its pleasant character. Foremost is the student mall, a skylighted, student-commons area which serves as the physical link between a two-story classroom unit on the north and a two-story physical education-shop-music-art-auditorium facility on the south which is stepped down the gently sloping site. Another feature is the unique treatment of recessed windows and entranceways with glass sloped to give a skylighted effect.

Tornado protection was integrated into the design and was included in the base bid. Necessary protection from high winds and structural collapse was achieved in core space on the ground floor of the south facility. An 11-inch reinforced concrete plate-slab was substituted for concrete pan-joists for the floor above the tornado-shelter area. The heavy construction mass of brick masonry and reinforced concrete results in fallout shelter for other spaces, both in the north classroom unit and the south unit. Because the tornado shelter is not self-contained, venting for pressure differential was not deemed necessary. An emergency generator furnishes power for shelter ventilation and lighting.



Photo: Paul S. Everett, Architectural Photography

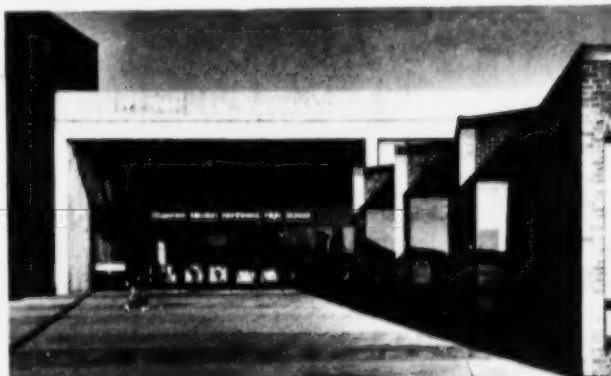
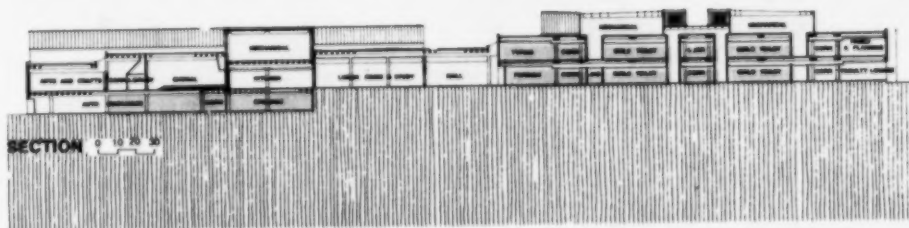
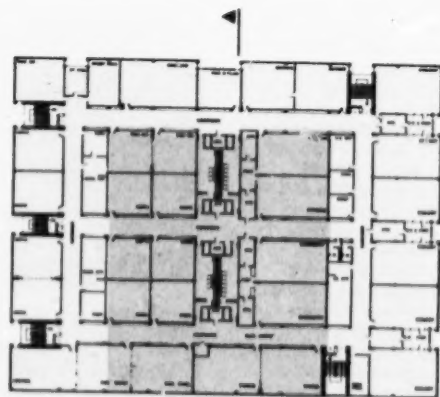


Photo: Paul S. Everett, Architectural Photography

10-12
Enrollment: 1963
Area: 303,396 sq. ft.
Cost: \$5,341,959.00
Shelter Location: Ground-Floor Locker Rooms
Cost of Shelter: \$0.00

Marshall & Brown, Architects & Engineers
Kansas City, Kansas

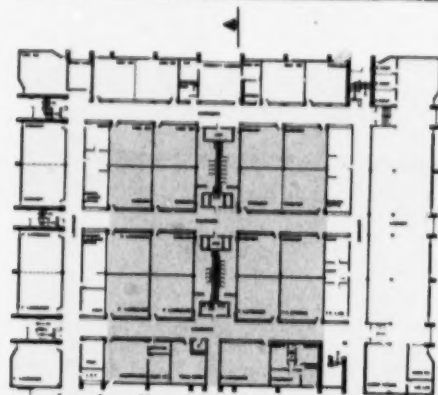
Tornado Shelter	Fallout Shelter
17,450 sq. ft.	92,264 sq. ft.
2,240 persons	8,200 persons
(7 sq. ft./person)	



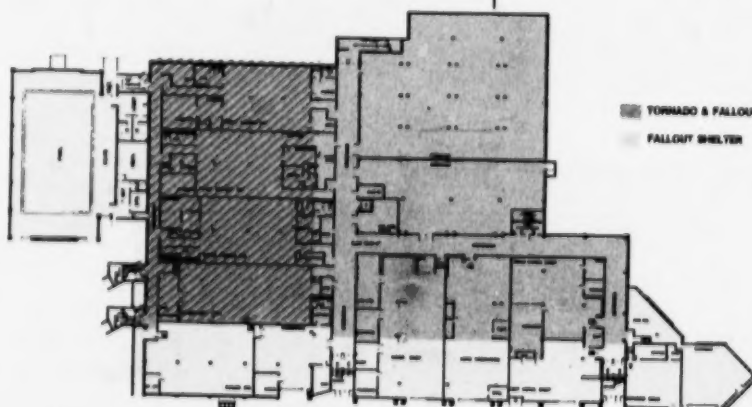
SECOND FLOOR PLAN

0 15 30

NORTH



FIRST FLOOR PLAN



GROUND FLOOR PLAN

TORNADO & FALLOUT SHELTER
FALLOUT SHELTER

MARSH

**MARSH
ELEMENTARY
SCHOOL
SHAWNEE,
KANSAS**

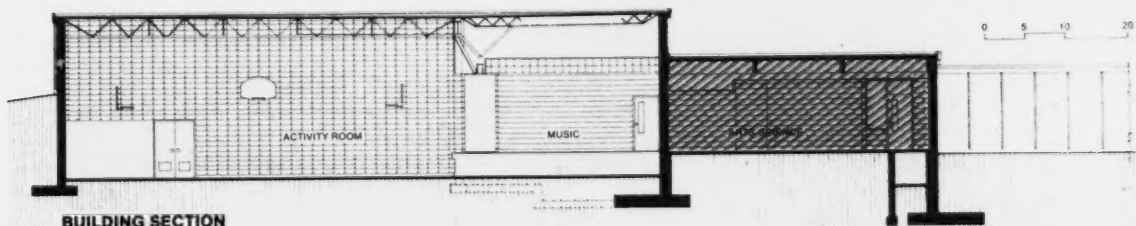
Designed for District No. 27 before unification into District No. 512, the Marsh Elementary School illustrates excellent integration of tornado protection with daily instructional purposes. Indeed, the casual observer might miss the tornado shelter which is the multipurpose room of this elementary school. The space also serves as the lunch room. Open instructional areas of the classroom portion, convenient relationships among the various service spaces, and attractive architecture all are evident and not affected by the tornado shelter design. The structural strength of a 5-inch thick folded-plate roof provided tornado resistance as well as the visual focus of the school. Surrounding core walls of 12-inch reinforced concrete provide protection at the horizontal. Openings into the space, while plentiful, are positioned to gain shielding from brick-faced enclosure walls at the perimeter of the building. Emergency power for ventilation was not provided for this shelter. The building was not designed with fallout radiation protection in mind; and, while the space does not meet DCPA recommended standards, significant fallout protection was achieved simultaneously with the tornado protection.

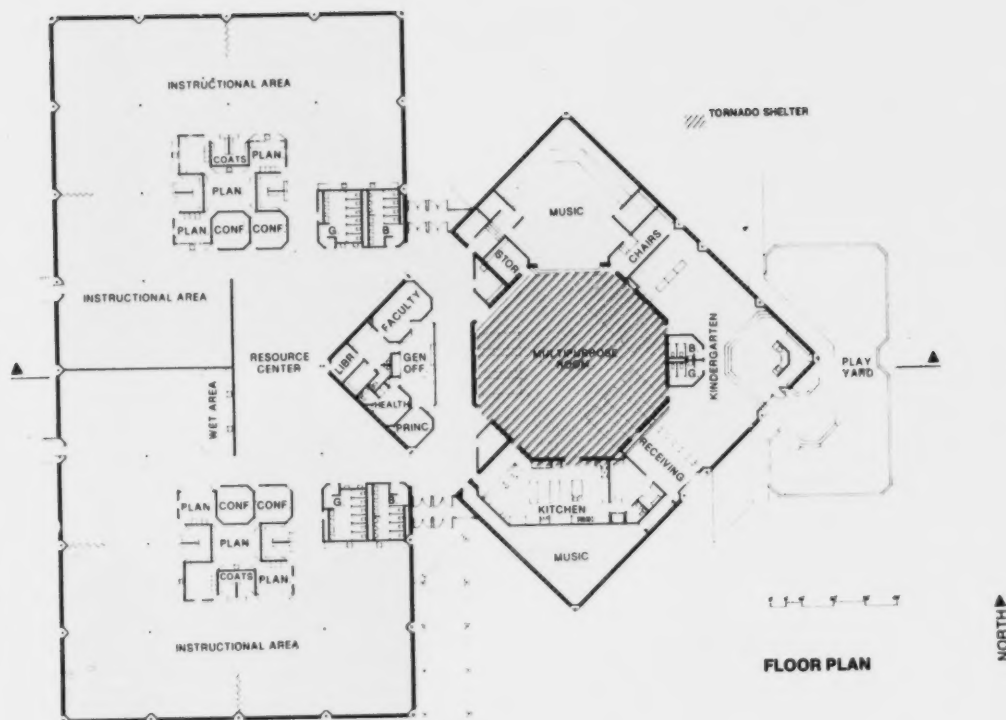
Horner & Krause, A.I.A., Architects
Kansas City, Kansas



K-6
Enrollment: 431
Area: 37,355 sq. ft.
Cost: \$603,707.00
Shelter Location: First-Floor Multipurpose Room
Cost of Shelter: \$6,400.00 (Architect's estimate) or \$0.17/sq. ft.

Tornado Shelter	Fallout Shelter
2,988 sq. ft.—net	Less than DCPA
600 persons	standards
(5 sq. ft./person)	300 persons





FLOOR PLAN

SEQUOYAH ELEMENTARY SCHOOL OVERLAND PARK, KANSAS

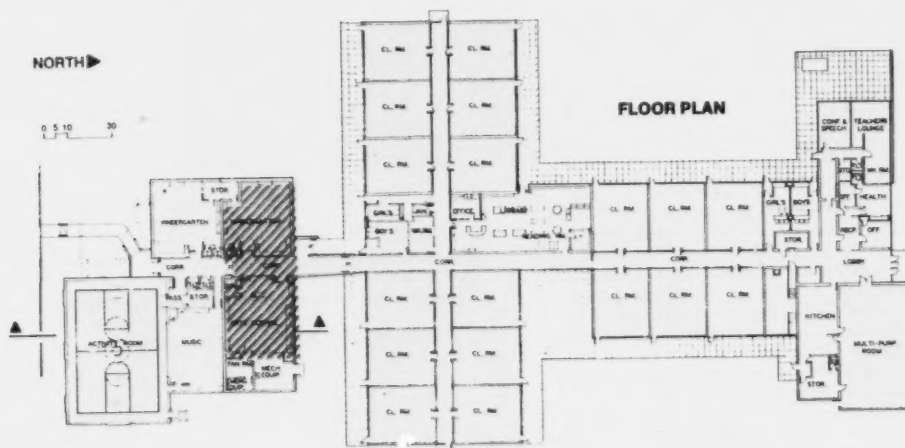
A one-story, slab-on-grade addition to this school, completed in 1968, included an activity room, two kindergartens, a music room, and an art-science room.

Attached to an existing finger-plan school, the activity room of the addition is stepped down on a sloping site so that the floor level is partially below ground.

Tornado protection was designed into the art-science classroom and a portion of the kindergarten area. Rock just below ground surface precluded a basement for this building. The tornado shelter also is a fallout shelter.

Protection at ground level was gained by means of a concrete pan-joint roof slab with 20-inch deep ribs and 4½-inch slab. Steel-joint construction typically occurs for the rest of the addition.

Exterior walls along the north side of the shelter area and interior walls around the shelter area are 12-inch reinforced concrete. An outside doorway into the shelter area is baffled against flying debris. A 7.5-KW gasoline-driven generator furnishes electrical power to shelter lighting and ventilation fans.



FLOOR PLAN

K-6

Enrollment: 363
Area of Addition: 11,312 sq. ft.
Cost of Addition: \$234,784.00
Shelter Location: First-Floor Kindergarten & Art-Science Classrooms
Cost of Shelter: \$20,000.00 (estimated) or \$1.77/sq. ft.

Addition by
Marshall & Brown, Architects & Engineers Kansas City, Kansas

Tornado Shelter
2,548 sq. ft.
380 persons
(6 sq. ft./person)

Fallout Shelter
2,548 sq. ft.
227 persons

SEQUOYAH

TOMAHAWK

**TOMAHAWK
ELEMENTARY
SCHOOL
OVERLAND PARK,
KANSAS**

Photo: Paul S. Kvett, Architectural Photography

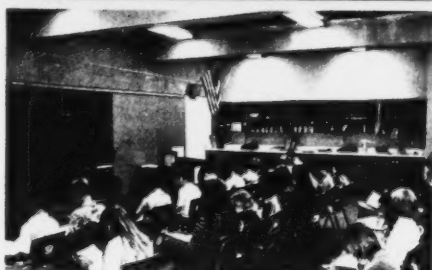
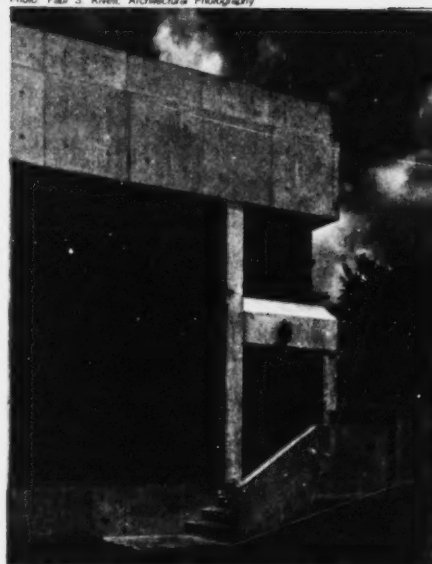
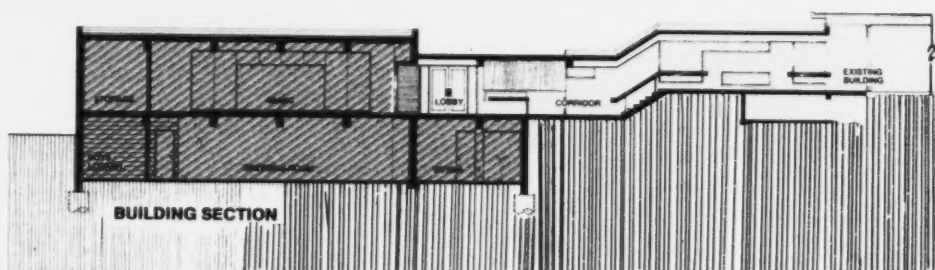
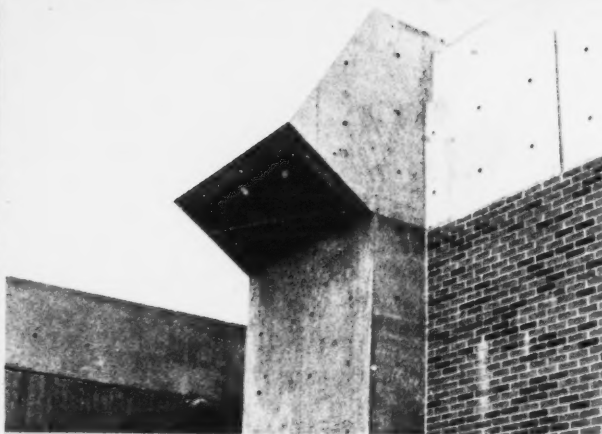


Photo: Paul S. Kvett, Architectural Photography

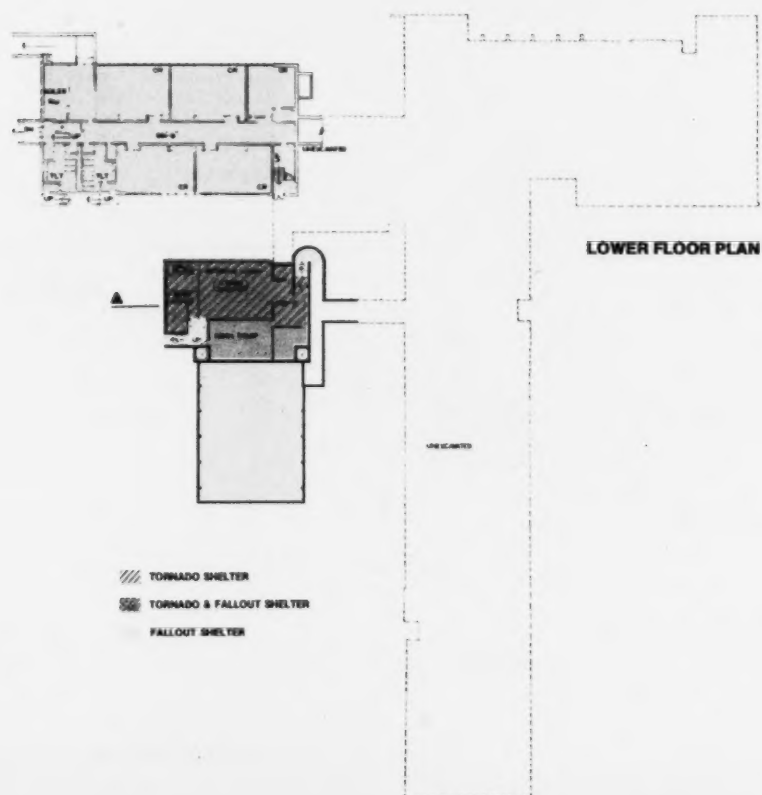
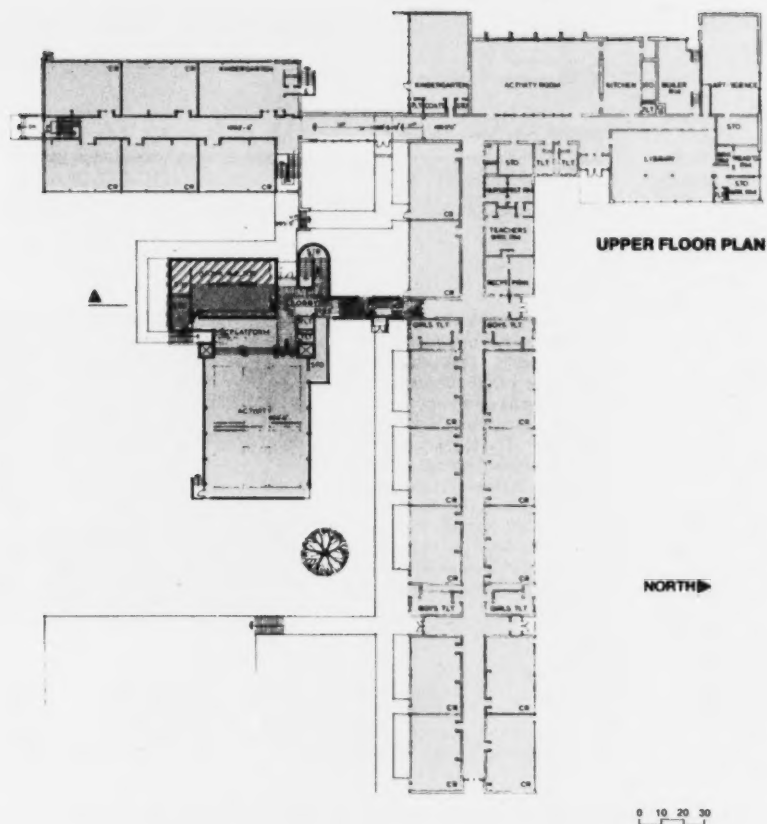


A distinguishing feature of the Tomahawk Elementary School is the landscaped court created by the relationship of this new addition to the existing finger-plan schoolhouse. The two-story addition stands free of the existing building and is connected by an enclosed corridor. The corridor also serves as the transition between floor levels since the addition is situated lower on the sloping site. Brick masonry and exposed concrete accents are the principal materials of construction for the addition. Tornado protection was designed into the first-floor music room and the partially depressed ground floor. A 6-inch slab-and-beam floor system and 12-inch reinforced-concrete walls provide protection at the ground-floor level. A 6-inch concrete roof slab also covers the music room shelter of the first floor, whereas precast-concrete double-tees cover the activity room. Walls of 12-inch concrete also enclose the music room and circulation areas. Two architectural features of the addition are sculptural brick and concrete shafts which permit venting of the shelter areas in the event of a pressure differential created by a passing tornado. Spring-loaded louvers at the tops of the shafts are protected from weather and flying debris by sloped concrete baffles. A 10-KW standby generator furnishes electrical power for ventilation fans and lighting of shelter areas. The heavy concrete construction of both tornado shelters also results in fallout radiation protection.

K-6
Enrollment: 467
Area of Addition: 9,610 sq. ft.
Cost of Addition: \$215,421.42
Shelter Location: Ground-Floor Dressing Rooms and First-Floor Music Room
Cost of Shelter: \$35,000.00 (estimated) or \$3.64/sq. ft.

Tornado Shelter	Fallout Shelter
3,000 sq. ft.	3,049 sq. ft.
540 persons	275 persons
(5 sq. ft./person)	

Addition by
 Marshall & Brown, Architects & Engineers
 Kansas City, Kansas



COMANCHE

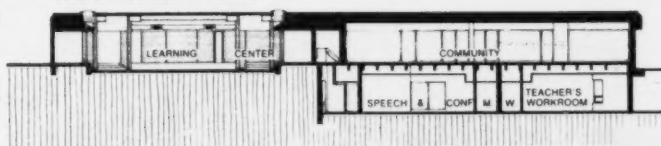
COMANCHE ELEMENTARY SCHOOL OVERLAND PARK, KANSAS

Comanche Elementary School was designed for construction in three phases. The basic first phase was completed in 1970; the second phase, a third classroom unit, was completed in 1971. The third phase is not yet under construction. Phases one and two have a design occupancy of 650 pupils. A school occupancy of 900 will be possible when the third phase is completed. This sculptural building was awarded a citation by the 1971 jury in AASA's Exhibition of School Architecture. The design solution consists of four large open spaces called "communities," each with flexible work area, special project area, team planning area, and activity room which functions as auditorium, theater, and gymnasium. Noisier activities such as music and dining are placed at a lower level below ground. That space serves as a tornado shelter as well. The tornado shelter was arranged so that it, too, would be enlarged with the second phase addition. Thus, the shelter occupancy is allowed to grow as the school grows. A 4½-inch concrete slab

DIAGONAL SECTION - PHASE 1



CROSS SECTION - PHASE 1



covers the lower level and provides the needed resistance against possible collapse of the upper floor. Load-bearing masonry walls carry light structural-steel roof framing of the upper floor. The tornado shelter offers significant fallout radiation protection; however, this does not meet recommendations of the Defense Civil Preparedness Agency. An emergency generator provides standby electrical power for tornado-shelter ventilation and lighting.

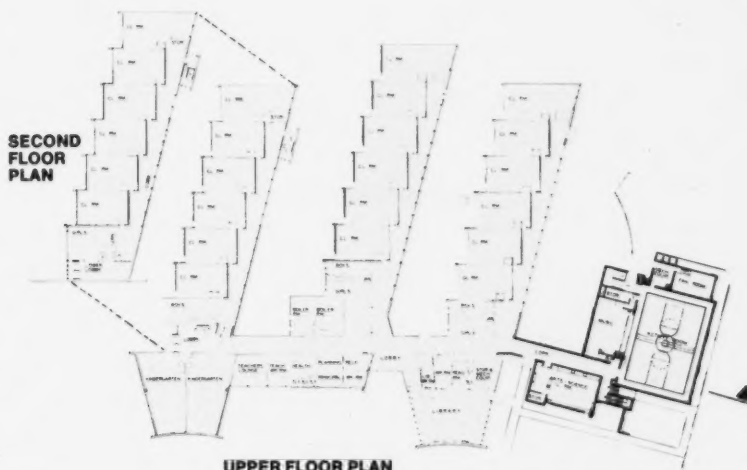


Photo: Paul S. Kvett, Architectural Photography

K-6

Enrollment: 557
Area: 39,263 sq. ft. (First Phase)
Cost: \$663,684.90 (First Phase)
Shelter Location: Lower-Level Dining Area
Cost of Shelter: Data Not Available

Tornado Shelter	Fallout Shelter
3,122 sq. ft.	Less than DCPA
695 persons	standards
(4 sq. ft./person)	280 persons



UPPER FLOOR PLAN

K-6
Enrollment: 620
Area of Addition: 15,860 sq. ft.
Cost of Addition: \$251,000.00
Shelter Location: Ground-Floor Lunch Room
Cost of Shelter: \$20,000.00 (estimated) or \$1.26/sq. ft.

Addition by
Marshall & Brown, Architects & Engineers
Kansas City, Kansas

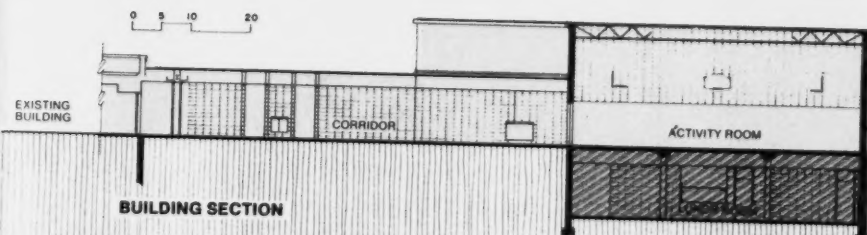
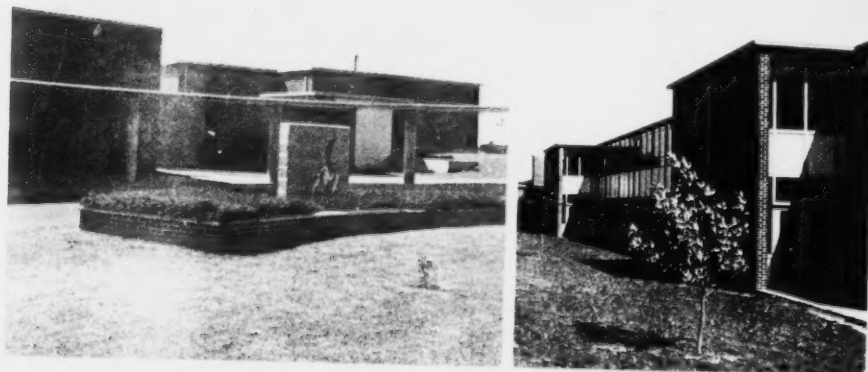
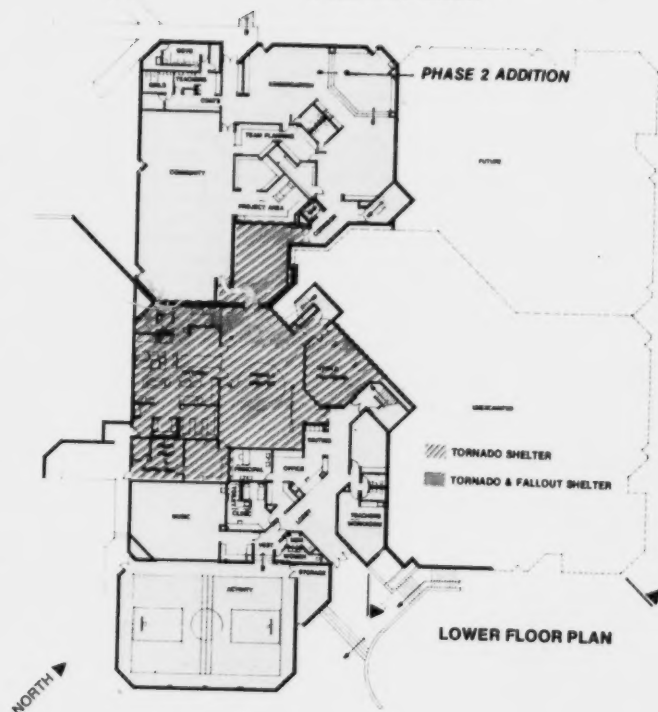
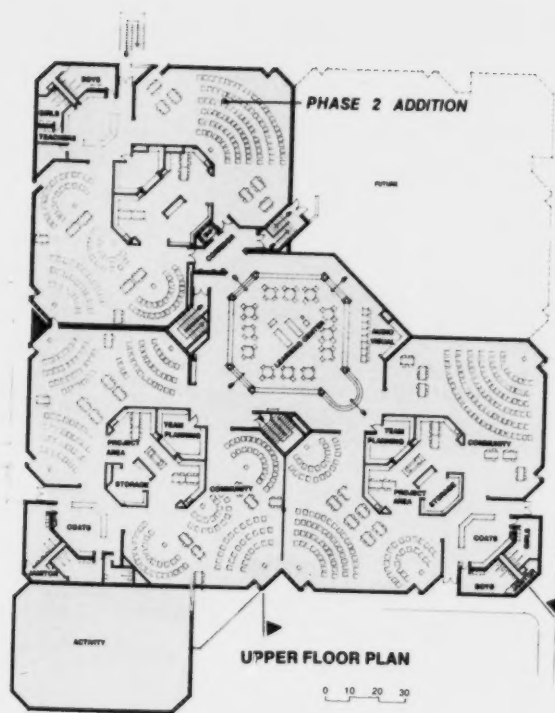
Tornado Shelter	Fallout Shelter
3,647 sq. ft.	3,647 sq. ft.
650 persons	325 persons
(5 sq. ft./person)	

NORTH

LOWER FLOOR PLAN



Marshall & Brown, Architects & Engineers
Kansas City, Kansas



A two-story addition to the north side of the existing Apache Elementary School is an extension of the principal circulation corridor which links three existing wings. Brick masonry of the addition matches existing brick and curtain-wall construction. The lower floor of the new addition is below ground; the upper level coincides with the first floor of the existing building. Facilities in the new addition include art-science, music, and activity rooms at the upper level and lunch room and kitchen at the lower level. The lunch room and kitchen double as shelter protecting from both tornadoes and fallout radiation. Upper-floor construction, consisting of a 6-inch slab-and-beam system, provides the required structural rigidity and mass over the shelter space. Structural-steel beams and joists compose the roof framing system. Venting for the tornado shelter is achieved by means of a vertical shaft. Entrances leading to the lower level—one directly from the outside—are baffled from airborne debris. A 10-KW generator provides emergency power for shelter ventilation and lighting.

APACHE

APACHE
ELEMENTARY
SCHOOL
OVERLAND
PARK,
KANSAS

MERRIAM

An open plan consisting of three main teaching suites—two classes each for two grade levels—is the organizational basis for the new Merriam Elementary School. Each suite has its own satellite library and audio-visual center. The multipurpose room is the center space about which the suites focus. It serves as auditorium, theater, and gymnasium, and the adjacent music room doubles as a stage. This schoolhouse was constructed under the bonding program of former District No. 110 through which all the schools of that district were provided with tornado shelter. Consequently, the Merriam School was designed with tornado protection as a goal from the outset. The school has a basement-floor level which serves as the lunchroom/cafe/teria as well as the tornado shelter. A 5-inch concrete slab for the floor above gives the necessary protection from tornado-induced loadings caused either by extreme winds or collapse of the light steel-framed roof system of the upper level. The 5-inch floor slab provides fallout radiation protection less than DCPA standards, even with the belowground location. One to two inches more of concrete for the slab would have provided better fallout radiation protection.



Photo: Paul S. Kivett, Architectural Photography

SOUTHEAST ELEVATION



LONGITUDINAL SECTION A



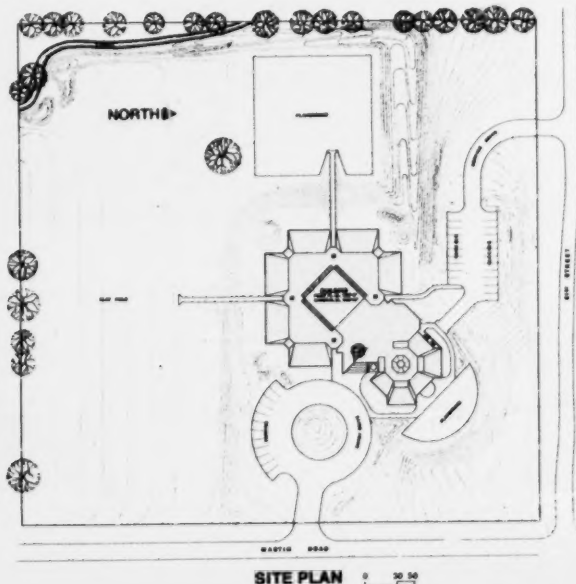
CROSS SECTION B

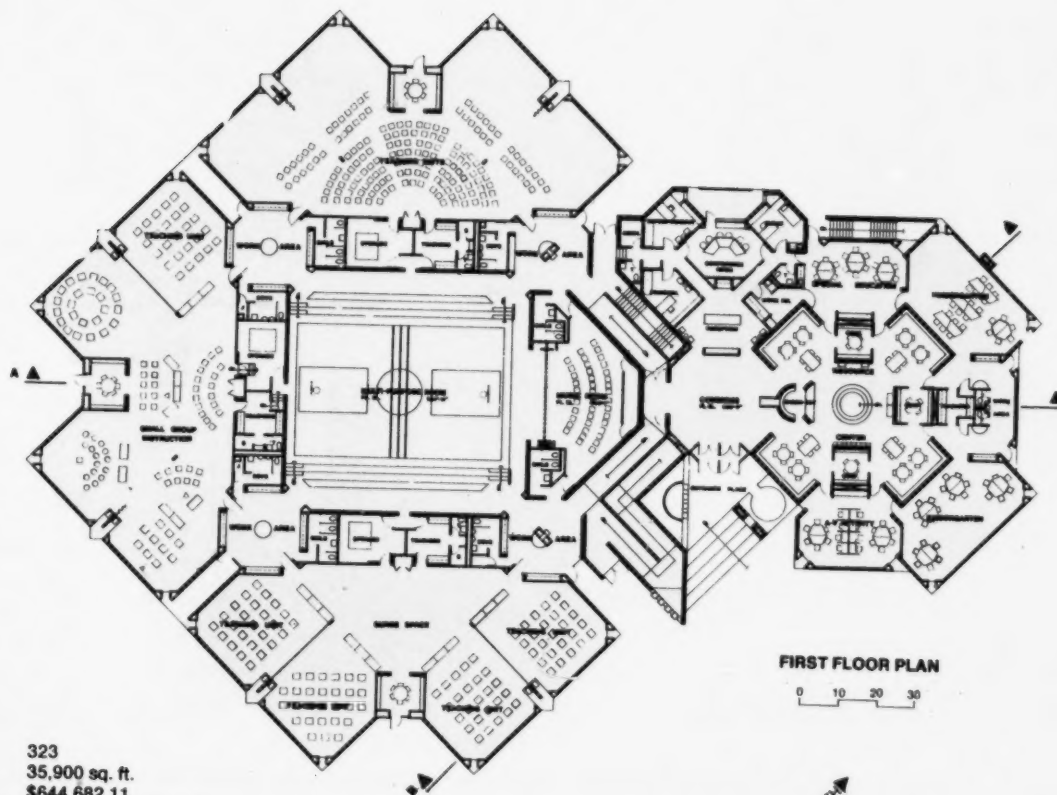


MERRIAM
ELEMENTARY SCHOOL
MERRIAM, KANSAS



Photo: Paul S. Kivett, Architectural Photography





FIRST FLOOR PLAN

0 10 20 30

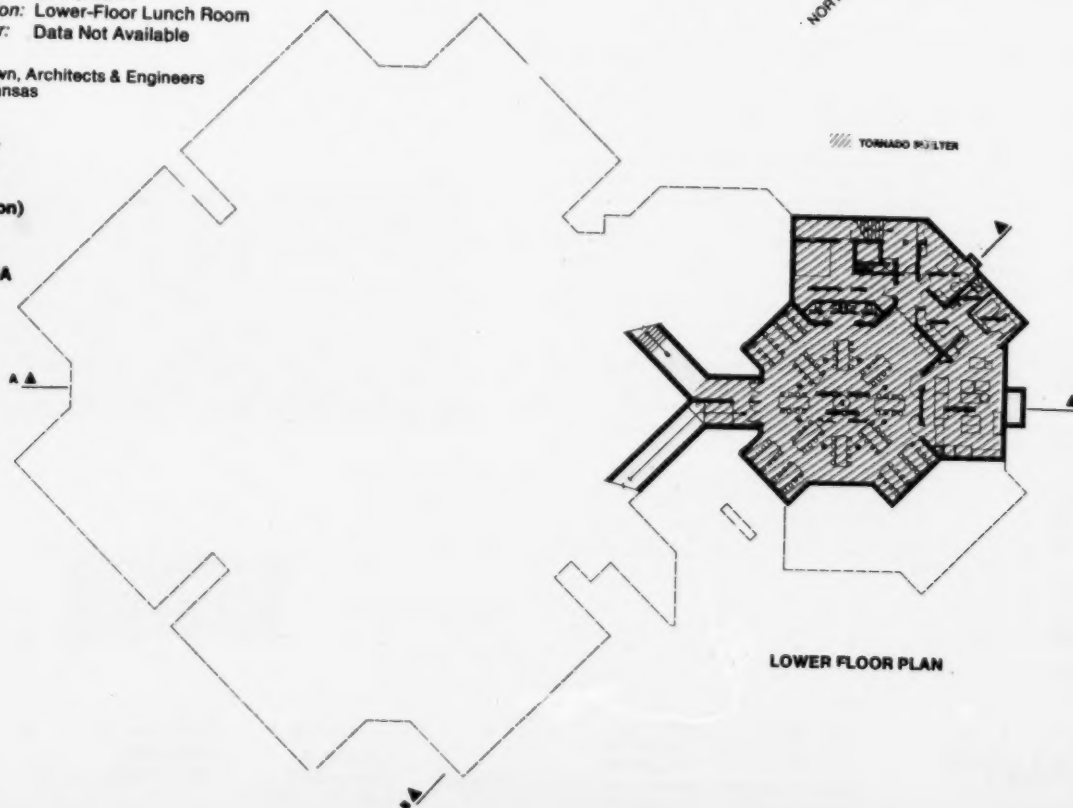
NORTH

K-6
Enrollment: 323
Area: 35,900 sq. ft.
Cost: \$644,682.11
Shelter Location: Lower-Floor Lunch Room
Cost of Shelter: Data Not Available

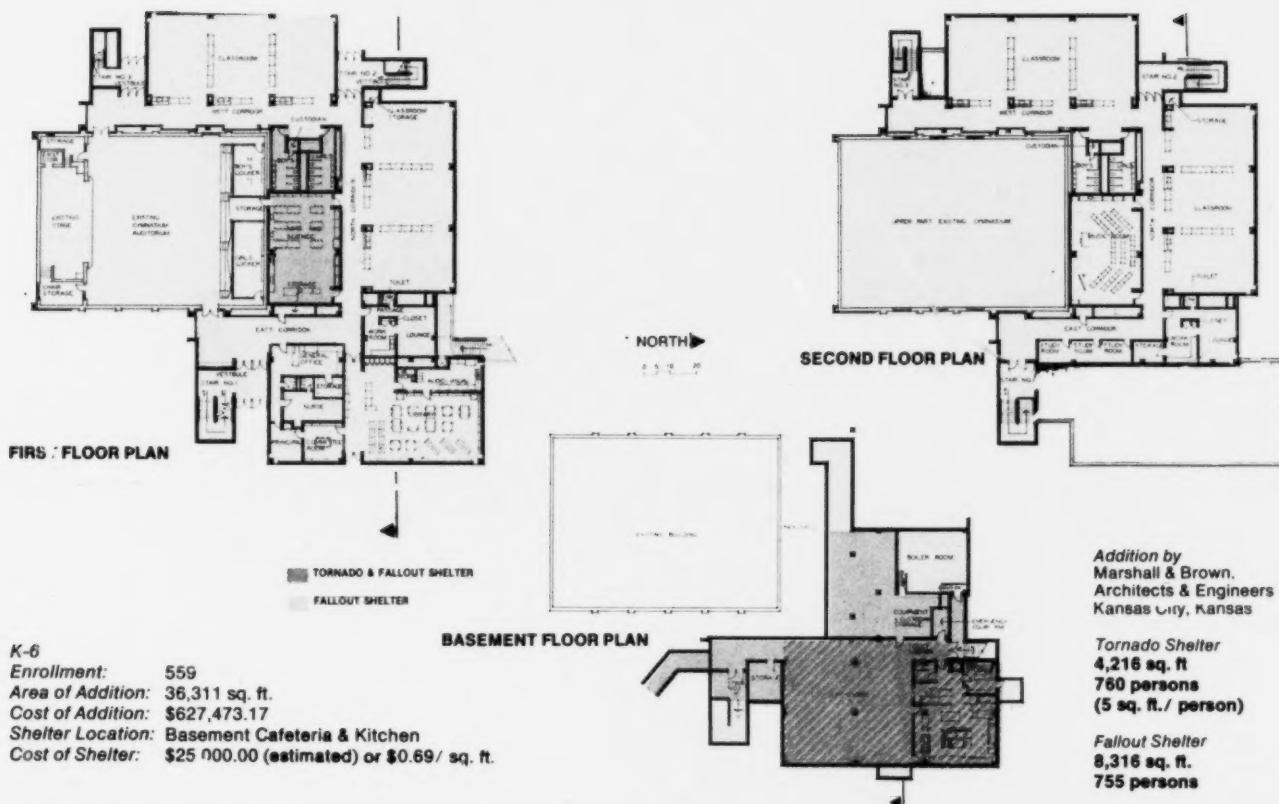
Marshall & Brown, Architects & Engineers
Kansas City, Kansas

Tornado Shelter
4,556 sq. ft.
534 persons
(7 sq. ft. / person)

Fallout Shelter
Less than DCPA
standards
375 persons



LOWER FLOOR PLAN



K-6
Enrollment: 559
Area of Addition: 36,311 sq. ft.
Cost of Addition: \$627,473.17
Shelter Location: Basement Cafeteria & Kitchen
Cost of Shelter: \$25,000.00 (estimated) or \$0.69/ sq. ft.

MOHAWK

This addition is unique among facilities added to the schools of former Overland Park Elementary School District No. 110. Mohawk School is one of two that needed no new educational space but which offered no reasonable possibility for creating suitable tornado protection in existing construction. Separate, single-purpose storm shelters were designed for these two schools to satisfy the objective of creating tornado protection in all of the former district's schoolhouses. The shelter for the Mohawk School was erected below ground in a playyard south of the existing one-story, slab-on-grade building whose light, steel-beam and fiber roof deck seemed to offer no possibility for tornado resistance. The roof of the shelter serves as a paved play area. Construction of the shelter is of reinforced concrete with 15-inch deep pan-joint roof covered with 6 inches of crushed rock and a 4-inch concrete play surface. The tornado shelter offers excellent fallout radiation protection as well. Stairways into the shelter space are baffled for protection from wind-blown debris. The shelter has its own exhaust fan and 7.5-KW emergency electric generator.



**MOHAWK
 ELEMENTARY SCHOOL
 MISSION, KANSAS**

K-6
Enrollment: 254
Area of Addition: 2,042 sq. ft.
Cost of Addition: \$47,204.00
Shelter Location: Below ground—Under playyard
Cost of Shelter: \$47,204.00 or \$23.12/ sq. ft.

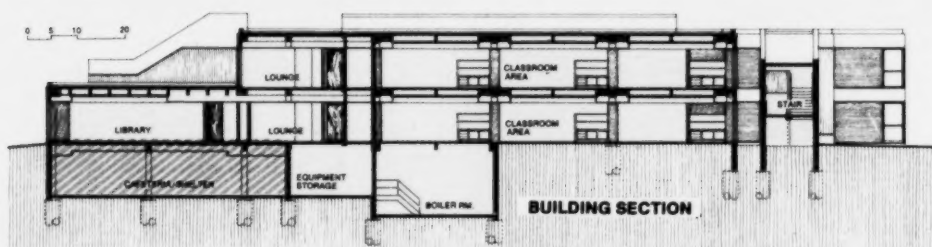
Tornado Shelter
 1,820 sq. ft.
 340 persons
 (5 sq. ft./ person)

Fallout Shelter
 1,820 sq. ft.
 170 persons

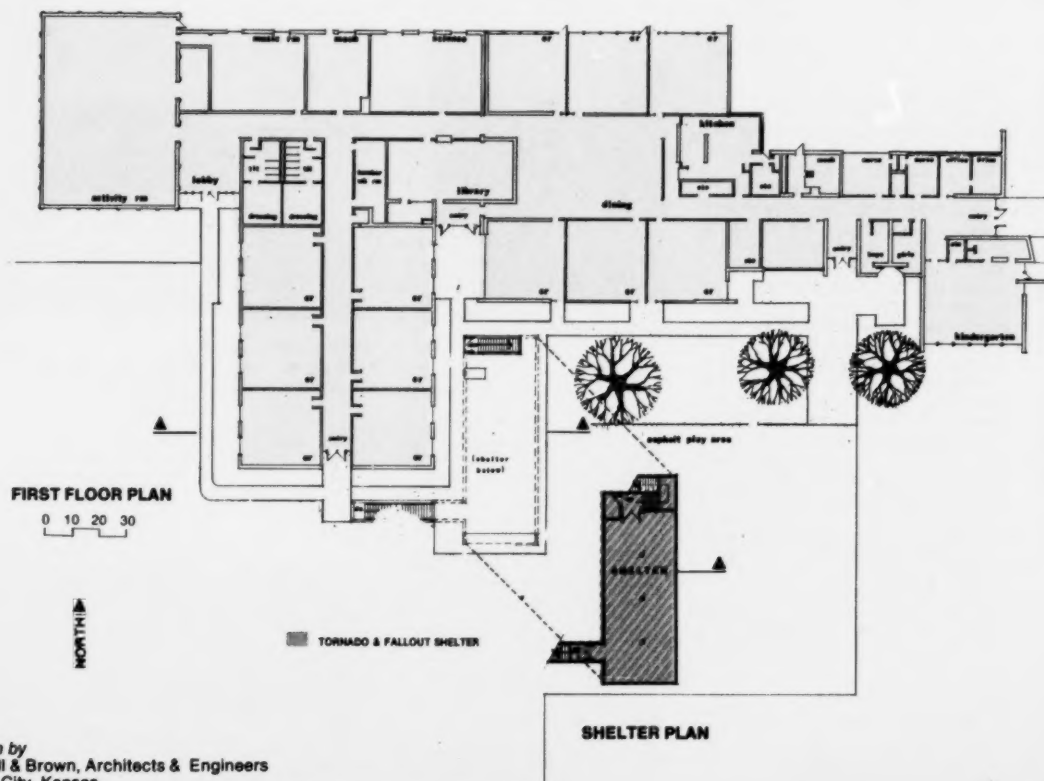
This elementary school comprises two buildings separated by a major trafficway. With the most recent addition, the two buildings now are connected by a tunnel under the roadway. A relatively large expansion was made to the existing north building, an auditorium and gymnasium. The new construction includes classrooms, library, administrative offices, cafeteria, and related service areas in three floors—two above ground and one partially below ground. The architects achieved an exceptionally pleasant building with this extensive new construction—instructional space which functionally works, and attractive visual results internally as well as externally. The basement level, housing cafeteria and kitchen, was designed with tornado protection and fallout radiation protection. In addition, core areas of the

first floor offer acceptable radiation shielding. The designed shelter space gains protection from the 6½-inch structural concrete slab but benefits as well from the 16-inch deep concrete pan-joint system of the roof. Core areas of the first floor gain radiation shielding from the reinforced-concrete structural framing system, brick-masonry exterior walls, and masonry-block interior walls. Stairways to the basement cafeteria and shelter space are constructed of concrete as added protection from failure due to tornadic winds and flying missiles. Emergency ventilation in the shelter space is provided by a positive-pressure system using two-speed fans and the basic building equipment. Ventilation equipment and emergency lighting for the shelter area are hooked to a 15-KW standby electric generator.

OVERLAND



OVERLAND PARK
ELEMENTARY SCHOOL
OVERLAND PARK,
KANSAS



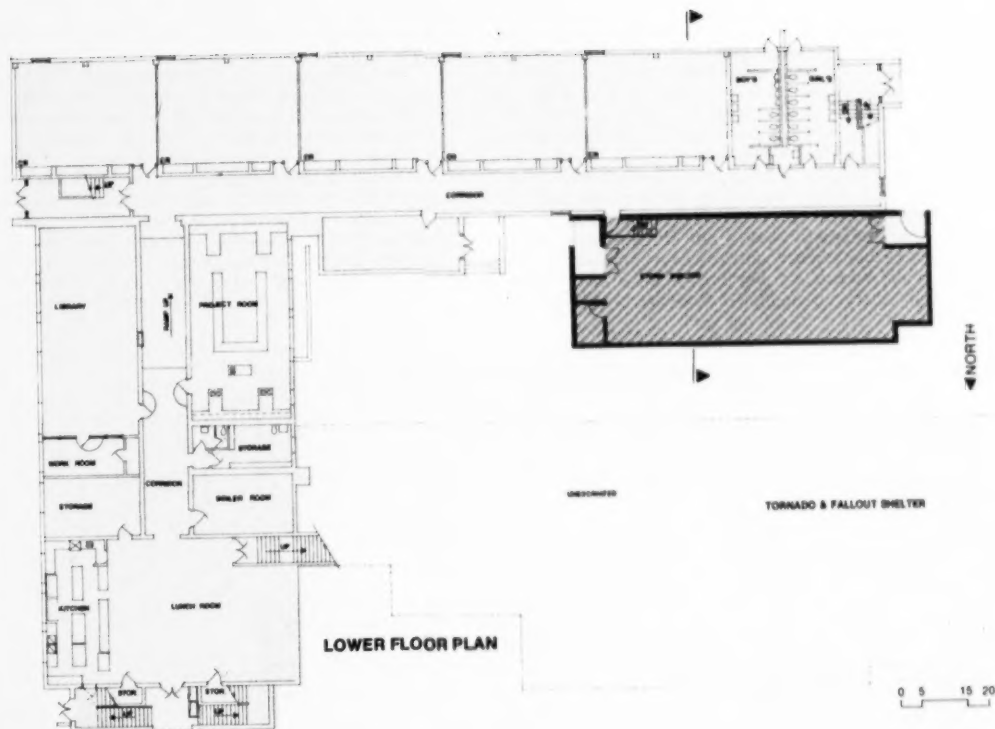
Addition by
Marshall & Brown, Architects & Engineers
Kansas City, Kansas

SOUTH PARK

SOUTH PARK ELEMENTARY SCHOOL MERRIAM, KANSAS

K-6
Enrollment: 404
Area of Addition: 2,428 sq. ft.
Cost of Addition: \$48,914.00
Shelter Location: Lower-Floor Appendage
Cost of Shelter: \$48,914.00 or \$20.15/sq. ft.

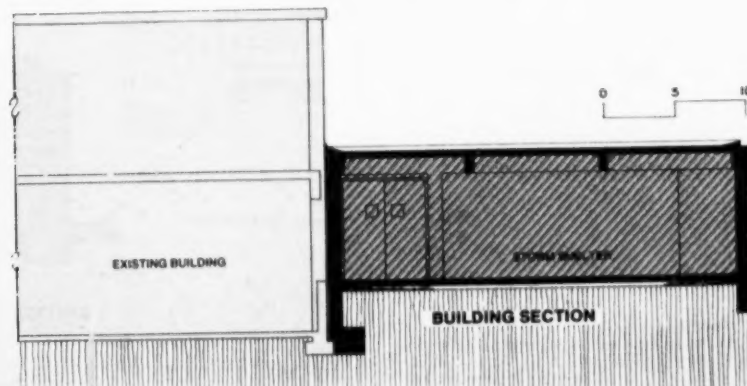
The addition to South Park Elementary School is a one-story, slab-on-grade structure of reinforced-concrete construction and was designed principally as a storm shelter. It is the other of two single-purpose tornado shelters designed for former District No. 110. As with the Mohawk School, South Park needed no additional educational facilities but offered no space of adequate strength to provide tornado protection. A separate shelter was added as an aboveground appendage in a court between two existing classroom wings. The shelter appendage is attached to the southmost wing along the court side and is accessible directly from within the schoolhouse. Unlike the Mohawk School shelter, this space is used frequently for indoor play and related activities because of its easy access. However, it is unfinished. Reinforced-concrete construction is used for walls and roof—12-inch exterior walls and pan-joint roof system with 4½-inch slab. Doorways are baffled with concrete walls. Venting of the space is provided by means of spring-loaded louvers adjacent to the west entrance. The louvers are partially screened from damage by flying debris. Fallout radiation protection is an added benefit of this tornado shelter. The shielding of the concrete roof is supplemented with a partially belowground floor for the shelter—a result of a sloping site in the court space. A 7.5-KW generator provides emergency electrical power for shelter exhaust fans and lighting.



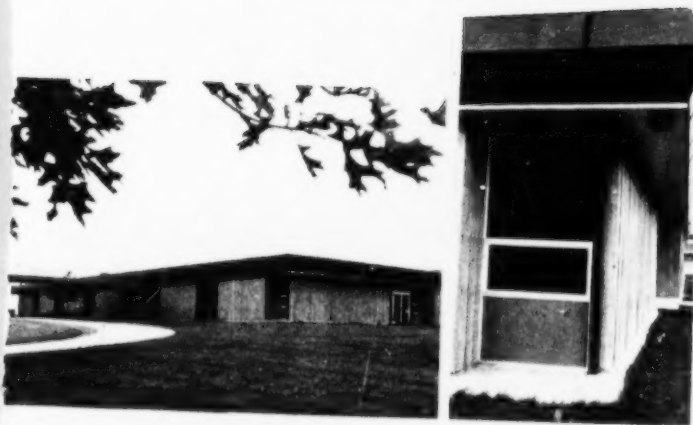
Tornado Shelter
2,428 sq. ft.
432 persons (5 sq. ft./ person)

Fallout Shelter
2,428 sq. ft.
216 persons

Addition by
Marshall & Brown, Architects & Engineers
Kansas City, Kansas



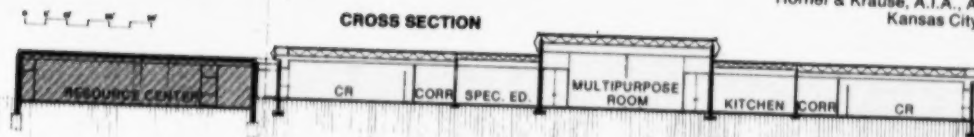
RHEIN BENNINGHOVEN



RHEIN BENNINGHOVEN ELEMENTARY SCHOOL SHAWNEE, KANSAS

This schoolhouse was constructed in two phases—the classroom unit in 1967 and the resource center in 1969. Data given includes both construction phases. The classroom unit is a steel-framed building enclosed with 6-inch precast-concrete panels. Concrete panels are textured with a vertical forming pattern. Interior classroom partitions are gypsum board and metal studs. The resource-center addition was designed to include tornado protection to meet the request of former School District No. 27 administrators. Exterior treatment of textured concrete matches the older classroom unit, but construction is poured-in-place reinforced concrete. Roof construction consists of a 10-inch concrete plate-slab carried on exterior bearing walls and one center column. Hence, tornado protection as well as fallout radiation protection were achieved in a one-story aboveground building which serves first as the school's resource center and library. Doorways were positioned to give maximum shielding from wind-blown debris.

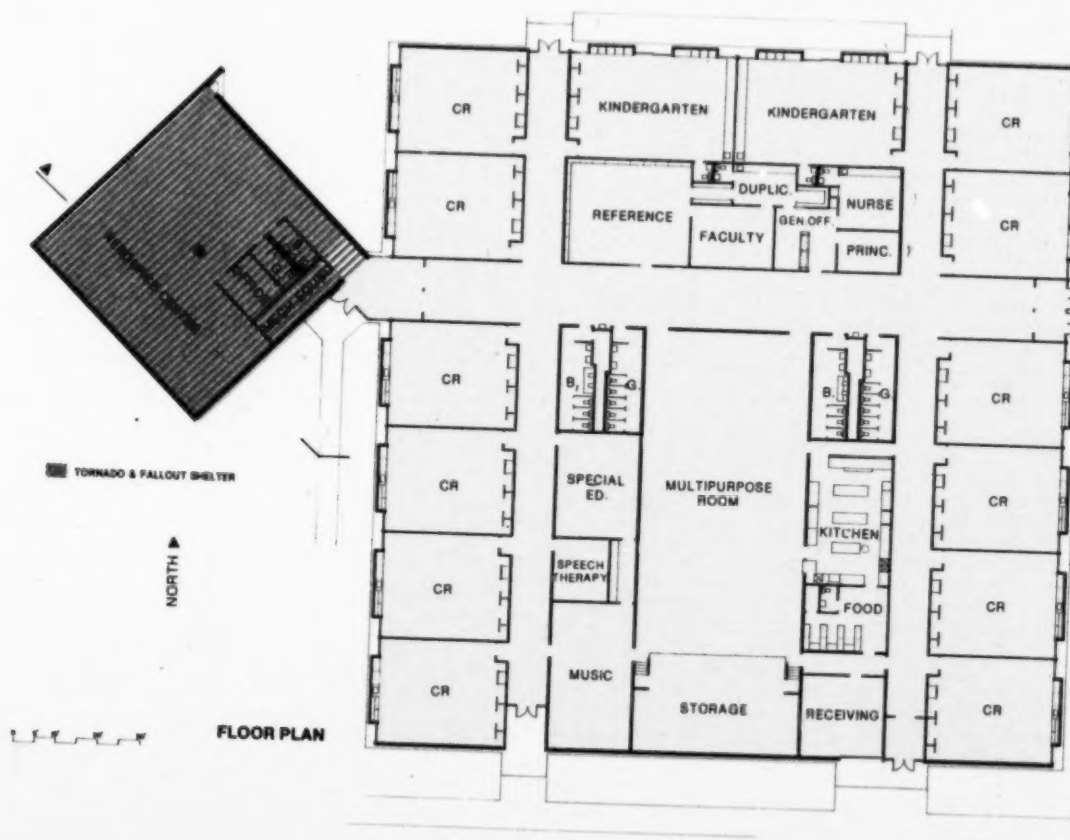
Horner & Krause, A.I.A., Architects
Kansas City, Kansas



Tornado Shelter
3,025 sq. ft.
390 persons
(7 sq. ft./person)

Fallout Shelter
3,025 sq. ft.
275 persons

K-6
Enrollment: 352
Area: 30,831 sq. ft.
Cost: \$453,681.00
Shelter Location: Ground-Floor Resource Center
Cost of Shelter: \$6,800.00 (Architect's estimate) or \$0.22/sq. ft.



DISTRICT DATA

	SCHOOL ENROLLMENT (1972-1973)	TORNADO SHELTER	FALLOUT SHELTER (● Meeting DCPA standards) (○ Less than DCPA standards)
Antioch Elementary School	340	●	
Apache Elementary School	620	●	●
Arrowhead Elementary School	298	●	●
Bagby Elementary School	263		○
Belinder Elementary School	304		
Bluejacket Elementary School	552		
Bonjour Elementary School	554		
Briarwood Elementary School	411	●	
Brookridge Elementary School	587		
Brookwood Elementary School	450	●	●
Carpenter Elementary School	692		
Cherokee Elementary School	646	●	●
Comanche Elementary School	557	●	○
Corinth Elementary School	505		●
Crestview Elementary School	355	●	
Diemer Elementary School	650		
East Antioch Elementary School	484	●	○
Flint Elementary School	448	●	●
Greenwood Elementary School	121		
Hickory Grove Elementary School	449	●	●
Highlands Elementary School	408		●
Linwood Elementary School	260		●
Marsh Elementary School	431	●	○
Merriam Elementary School	323	●	●
Mohawk Elementary School	254	●	●
Moody Elementary School	714		
Nall Hills Elementary School	634		
Nieman Elementary School	549	●	●
Osage Elementary School	200	●	●
Overland Park Elementary School	559	●	●
Pawnee Elementary School	828	●	●
Porter Elementary School	439		●
Prairie Elementary School	567		●
Rhein Benninghoven Elementary School	352	●	●
Ridgeview Elementary School	450		
Roeland Park Elementary School	262		○
Roesland Elementary School	515		●
Rosehill Elementary School	701		○
Rushton Elementary School	331	●	●
Santa Fe Trail Elementary School	507	●	●
Sequoyah Elementary School	363	●	●
Shawnee Elementary School	550		
Skyline Elementary School	153		●
Somerset Elementary School	444		
South Park Elementary School	404	●	●
Tomahawk Elementary School	467	●	●
Trailwood Elementary School	689		●
Valley View Elementary School	441		●
West Antioch Elementary School	274	●	●
Westwood View Elementary School	255	●	●
Broadmoor Junior High School	1,057	●	●
Hillcrest Junior High School	1,456		●
Hocker Grove Junior High School	1,119	●	
Indian Creek Junior High School	1,040	●	
Indian Hills Junior High School	896		●
Meadowbrook Junior High School	867		○
Milburn Junior High School	1,022	●	●
Nallwood Junior High School	1,261	●	●
Old Mission Junior High School	1,004	●	●
Trailridge Junior High School	1,159	●	●
Shawnee Mission East High School	1,910		●
Shawnee Mission North High School	1,911	●	●
Shawnee Mission Northwest High School	1,963	●	●
Shawnee Mission South High School	2,357	●	●
Shawnee Mission West High School	2,286	●	●
	44,008		

ACKNOWLEDGEMENTS

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